The Blast Furnace and Steel Plant

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The Editor's Point of View

THE New Year was ushered in with two phenomenal achievements. Power was transmitted by wireless from the General Electric plant in Lynn, Mass., and motors were operated at a distant point, without physical contact.

Speech was transmitted across the Atlantic ocean, and voice speaking in New York City was heard distinctly in London.

Only imagination can comprehend the ultimate possibilities which these developments portend.

How did these things happen? Surely not by accident.

They resulted, purely and simply, from the fruits of concentration.

What was originally a little idea inflamed the imagination of scientists. They went to work; they tried, they failed; they tried again; they adapted, redesigned, compared; they SUCCEEDED by concentrating every available resource upon the given problem.

Such likewise has been the history of the Steel Industry. Nowhere can be found more vital necessity for concentration and nowhere are the ultimate rewards more quickly apparent.

Crudeness has been replaced by flexibility, Wastes have been replaced by marvelous recoveries. Danger has been reduced to safety.

The entire progress has been a series of successive studies bound together by concentrated co-operative effort whose complete aim has exerted a broadly humanizing influence upon the lives of millions, employed and otherwise.

Without concentration, we would still be blowing a 100-pound charge of iron by footpower bellows—and voicing the language of apes.

The Indian Iron and Steel Industry and Its Probable Development

A Brief Review of the Growth of Iron and Steel Manufacture in India—Modern Steel Plants Are Successful in Making High Grade Products Very Cheap Because of Economic Advantages.

By J. V. McCARTNEY*

THE production of iron in India has existed from very remote times. It is most probable that the first metal was produced by the Kolarians, that branch of the brown race which swept into Northeast India from the base of the Himalayas long before the dawn of history and who now inhabit the hill jungles of Central India. They early learned the use of iron, from which they fashioned small axes to cut down the jungle, forming clearings for cultivation. Even at the present day, iron is smelted from the rich ores found in the hills peopled by these aborigines, in much the same primitive way that it always has been.

These primitive furnaces consist of a shaft of specially prepared clay some 8 or 10 feet high which slopes from a base diameter of 4 or 5 feet to a top diameter of perhaps 3 feet. This shell of clay rests over a shallow pit from which the slag is drawn through a small cinder notch. Blasts of air are forced through several tuyeres by pressure upon small drum-like bellows attached to hollow bamboo pipes. The operators, usually boys, stand with a bellows under each foot and, simulating a walking motion, force a steady stream of air through the tuyere; each tuyere having one pair of bellows with bamboo pipe outlets converging at the tuyere. Alternate layers of charcoal and picked ore are charged into the top of the furnace, nearly filling the shell before the fire is applied at the tuyeres. No further charging is done after the operators have started the bellows, forcing air through the furnace. Frequent changes of boys to operate the bellows are made, and from time to time a little slag is run off. It usually requires several days to reduce the charge to molten iron, after which the furnace is allowed to cool and then the upper part of it torn down and the rough mass of iron removed, the whole operation requiring about a week. A new shaft is then built for the next charge.

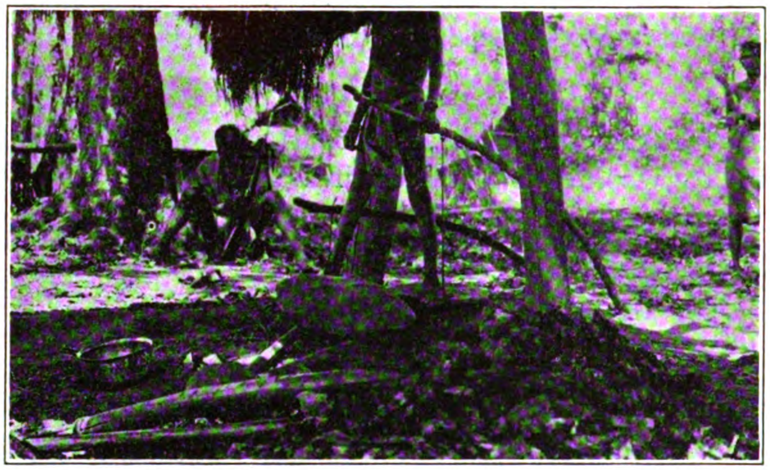

FIG. 1

A native forge. This type of bellows is used to force air through the tuyeres of the native blast furnace.

As one stands in the small cleared space occupied by one of these furnaces in the jungle and notes the close resemblance of this primitive smelting to that of our modern blast furnace, he is certain to be reminded that there is nothing new under the sun, especially under the Eastern sun.

From this charcoal iron, native axes, arrowheads and points for their primitive wooden plows are made. Several interesting examples of this early art are to be found in India today, notably the iron pillar of Raja Dhava at Delhi. This is thought to have been erected in the third century A. D. It is a solid shaft of very pure wrought iron, nearly 24 feet in length and bears a Sanskrit inscription which is as sharply defined and legible as on the day it was cut. Other examples are the heavy wrought iron beams of rectangular shape found in some of the temples of Southern India. Only in rather recent years has Western science produced forgings equal to these. The earliest production of steel in India occurred more than 2,000 years ago. They have long been noted for the famous Wootz steel which was used largely in the manufacture of sword blades and similar articles.

Early Attempts to Make Iron on a Commercial Scale Unsuccessful.

The first attempt to manufacture iron on a large scale was made by the Barakar Iron Works, which was organized in 1875, and blast furnaces of 80 tons capacity erected at what is now Kulti near the Jherria coal fields, about 150 miles from Calcutta. The first effort resulted in failure. The works were restarted in 1881, and in 1889 the company was reorganized as the Bengal Iron & Steel Company. For some unexplained reason the manufacture of steel was unsuccessful and in 1904 the steel plant was abandoned. Recently a reorganization has been effected and the company is now operating as the Bengal Iron Company and is devoting itself to the production of pig iron and castings, particularly railway sleepers and cast iron pipe, in the manufacture of which it has been very successful.

The pioneer effort for the establishment of an iron and steel industry on a really large scale belongs to Jamshed N. Tata, a wealthy Parsee of Bombay. The necessary preliminary investigation incident to the selection of a suitable site was started in 1902 and in 1907 the Tata Iron & Steel Company was formed. A site was selected about 155 miles from Calcutta on the Bengal-Nagpur railway near the village of Sakchi (since changed to Jamshedpur in honor of the founder) and the erection of the plant begun by Kennedy-Sahlin & Company, Mr. Julian Kennedy being responsible for the blast furnace design. The steel plant equipment was taken care of by Mr. Sahlin in Europe. The plant went into operation in 1911-12; two blast furnaces of 350-ton capacity, four basic open hearth furnaces of 40 tons capacity, a combination rail and structural mill, 16-in. and 10-in bar mills and coke oven batteries supplying coke to the blast furnaces.

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Operating Difficulties Experienced in First Large Scale Operation.

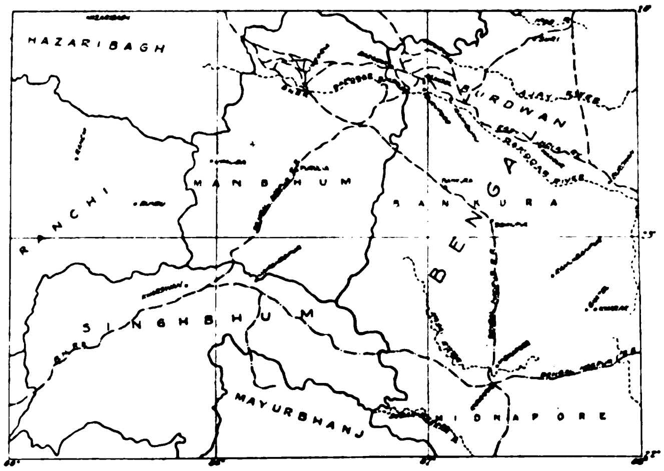
At first considerable operating difficulty was experienced due largely to the inexperience of the native help, but gradually these troubles were overcome so that during the period of the war large quantities of materials were delivered to the government for the Mesopotamian and other operations in addition to the Indian railways and private companies. For the success of this large development credit is due Mr. C. P. Perin, Consulting Engineer of New York, who has been identified with the undertaking in a consulting capacity since its earliest stage and to whose vision much of the later development has been due. The additions to the above plant now in operation are one 300-ton blast furnace, two 500-ton blast furnaces, a 98-in. plate mill, three 60-ton basic open hearth furnaces and four 50-oven coke batteries. Provision has been made for five additional 500-ton blast furnaces. Certain other additions are under way and others contemplated which will be laid down as conditions warrant to take care of the several subsidiary plants now building. The success of this venture has led to several new developments being undertaken, notably that of the Indian Iron & Steel Company at Burnpore near Asansol on the East India railway. This company will soon have two 350-ton modern blast furnaces in operation and later expect to erect open hearth furnaces and mills to convert the total pig iron output into steel shapes, the design and erection of the blast furnaces being in charge of Arthur G. McKee & Company. Provision has been made for four additional blast furnaces to be erected at a later period.

Another recent installation of importance, the only one in South India, is that of the Mysore Iron and Distillation Co. of Bhadravati, in Mysore State. It has one 60-ton charcoal furnace using charcoal as fuel from the distillation plant which is part of the layout. This furnace is designed so that later a production of 100 tons will be possible. Sufficient scrub jungle is available to permit of continual operation over a long period of years. In addition to these recent developments there are a number of proposed developments, the most important, at the moment, being that of the United Steel Company of India who propose to erect a complete modern iron and steel plant near their ore deposits in the Singhbhum District. The growth of the industry as above outlined will extend over a period of years till 1926 at which time an investment of Rs. 444,000,000 will have been made and 125,000 employees (men) with an annual payroll of Rs. 60,000,000 or nearly three times the present force will be required.

The Ore and Coal Deposits of India Are Extensive.

Recent surveys have shown that there are some 20 billion tons of high grade ore within an average distance of 150 miles of the coal bodies. These deposits occur in Bihar and Orissa and Central India and are largely hematite, analyzing 64 to 69 per cent iron, .048 to .135 P., .020 to .036 S., and 1.65 to 4.08 silica. There are some magnetite deposits and also some carbonate deposits in this same area; the latter, however, do not run very high in iron.

Extensive manganese ore deposits occur in Central India at Gwalior, Bhopal and Indore and in the Central Provinces at Magam and Chindwara. In Southern India there are important deposits in Madras Presidency at Bellary, Nilgiri Hills and Vizagapatam and in Mysore State at Shimoga, Kadur and Tunkur. In Bihar and Orissa there are deposits at Gangpur in Singhbhum.



MAP OF BIHAR AND ORISSA

The Bengal Iron Company is located near Baraker at Kulti, the Indian Iron and Steel Company at Burnpore near Asansol, both of these being located approximately at 87 deg. west and 23½ deg. north; the Tata Iron and Steel Company at Jamshedpur.

The principal coal areas are known as the Jherria and Ranigunj fields, the former being located west of Asansol, and the latter a little to the southeast of this same city. Other areas are included in the districts of Manbhum and Singhbhum.

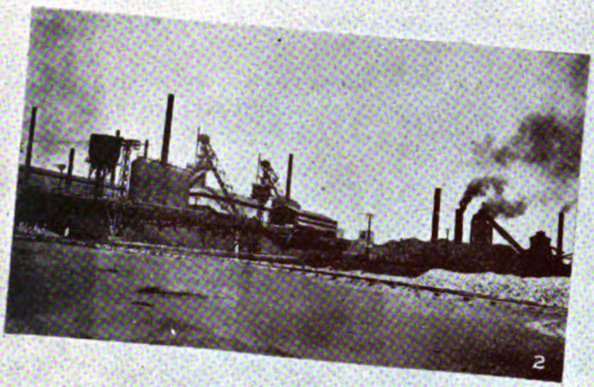
The ore for the Tata plant is obtained in the district of Singhbhum and also the principal ore deposit of the Bengal Iron Company is in this same district.

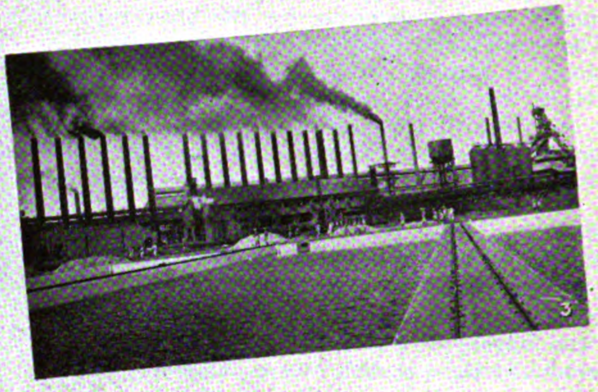
The known Indian coal deposits of importance lie in the area between the Ganges river on the north and the Godavari river on the south. The largest deposits of high grade coal are confined to a still smaller area in Northern Bihar and Orissa and comprise three fields, the Ranigunj field containing some 20 billion tons of coal of all grades, mostly inferior and unsuited for making blast furnace coke; 500 million tons, however, are of first quality; the Jherria field, with about the same amount of first quality coal, and the Karanpura field further west, containing some 600 million tons of good coking coal. Dolomite deposits in this area are sufficient for present and immediate future needs.

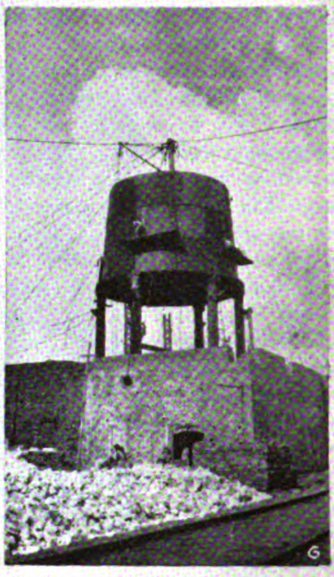
All of the iron and steel companies, with the exception of the one in Mysore State using charcoal, obtain their coal and iron ore from the districts of Manbhum and Singhbum and the native states of Keonjhar and Bonai in Bihar and Orissa.

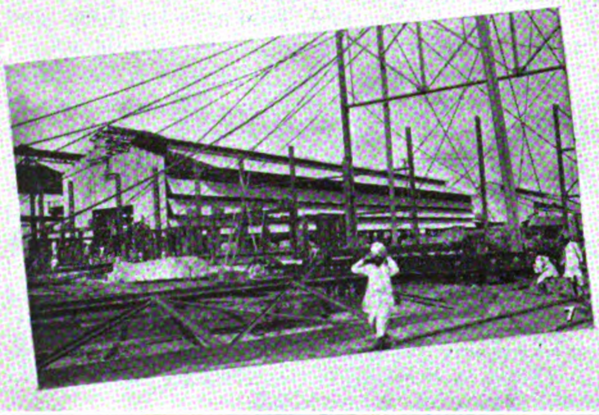
Shipping Facilities.

For several years there has been a shortage of railway equipment of all kinds, a condition largely due to the war, during which considerable rolling stock was transferred to the seat of the operations in the near East and little new equipment could be obtained. The iron and steel industry has felt this shortage in obtaining raw materials and in the shipment of finished products. But, the particular equipment of the Indian railways (and India is little worse than Europe in this respect) has been specially troublesome to this new industry due to the fact that their standard rolling stock is entirely unsuited to the handling of coal, coke, ore, limestone and such finished materials as rails, shapes and plates. It is important that either the railways operating in the iron









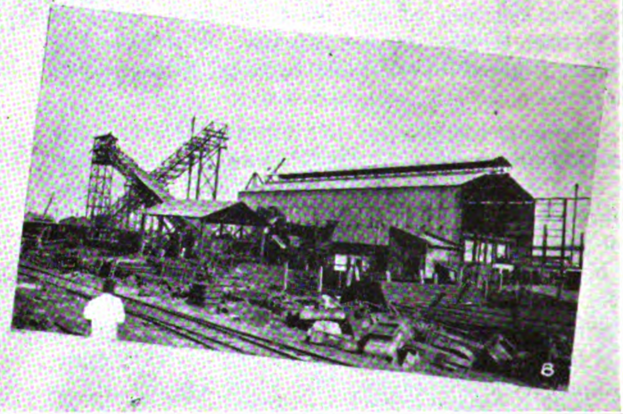


FIG. 2—*Two 450-ton blast furnaces at the Tata Iron and Steel Company.*

FIG. 3—*Boiler plant and power house at the works of one of the Indian steel plants. Filtration beds in foreground.*

FIG. 4—*150-ft brick chimney under erection at one of the Indian iron and steel plants. Bamboo scaffolding of this type is used by the native workmen on all construction.*

FIG. 5—*On the coke bench of the non-recovery batteries at the Tata Iron and Steel Company. This arrangement requires much labor; the new, modern coke plant avoids this difficulty.*

FIG. 6—*Shell of a blast furnace recently erected (now in operation) at one of the Indian steel plants.*

FIG. 7—*Plate mill buildings and reheating furnaces now under erection at plant of the Tata Iron and Steel Company.*

FIG. 8—*A battery of by-product coke ovens and coal handling equipment under construction at the works of the Tata Iron and Steel Company; with hopper cars (wagons) in foreground. These ovens are now completed.*

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and steel district or the iron and steel companies themselves be equipped with 50-ton gondola hopper wagons for the handling of raw materials instead of 10 and 20-ton side door, covered and uncovered goods wagons and with suitable flat wagons for the shipment of rolling mill products. Some of the larger equipment is now in use, but is entirely inadequate to the needs of this rapidly expanding industry.

Labor Conditions and Problems in the Indian Steel Industry.

India has an area of about two-thirds that of this country and supports a population of 315,000,000 people varying in density from 50 per square mile in certain hill jungles to over 500 per square mile in the fertile valley of the Ganges.

In a country as densely populated as India there is no danger of a labor shortage, although some seasonal difficulty is usually experienced in holding the unskilled labor. As stated above, the principal known deposits of iron ore and coal are located in the northeastern part of the triangular plateau forming the Indian peninsula, an area bounded on the north by the Ganges river and its tributaries and on the south by the Godavari river and its tributaries. This area is populated principally by the aboriginal Kols and Santhals, the density of the population varying from 50 to 250 inhabitants per square mile in the less densely populated portions to about 400 per square mile in the most densely settled sections. These people are agriculturists and during the growing season they return in large numbers to their fields, thus producing a temporary shortage, particularly at a new site requiring the recruiting of labor from the virgin jungles, but this has not been found serious in the case of established industries. As the women and children work as well as the men, the supply of available labor becomes very nearly the total population, this being specially true at certain seasons.

The skilled and semi-skilled labor for the shops and mills has been recruited largely from the Skihs of the Punjab who are artisans as a people if not by caste, from the Bengalis and the people of Bhutan, as well as from the Mohammedans. There are also large numbers of Madrasis, Biharis and a sprinkling of others from distant provinces. The unskilled or coolie labor, costing on an average 7 to 8 annas (15c) per day, can only be replaced by machinery and not by higher caste natives who are entirely unsuited physically, if not by caste restrictions, to perform arduous work in a blazing hot sun. It is still to be demonstrated, however, that certain work, such as excavations, or the handling of raw materials at the mines, can be done more cheaply (the present rate will decrease with the decrease in living costs) or more quickly by machinery than by coolies. But except for such work, it is quite clear from recent experience that machinery of the most modern design should be used. This applies particularly to operation work such as coal and ash handling at boiler plants, the handling of ore at the furnaces, or coke at the ovens. No doubt much of the rougher work first mentioned will eventually be done by machinery, but at present there is a distinct lack of labor sufficiently skilled in the handling of such equipment to make the replacement of the coolie either advisable or possible.

Regarding the skilled or semi-skilled labor which costs on an average Rs. 1/8 per day (0.50), it may be generally stated that it will require many years of patient training, if not a few generations, to bring it up to Western standards, but regarding this I wish to point out a condition that is frequently lost sight of in comparing Indian labor, both skilled and unskilled, with that of the West. While most Eastern labor, particularly that of the tropics, compares very unfavorably with labor of the West, it must be remembered that Western ern labor in a temperate climate, especially if it has long been in the tropics. The same is true of Eastern labor from temperate climates, but not to so marked a degree. It has been found that where it is possible to carefully

FIG. 9—*Kal junglys on their way to work at Gua in the newly opened ore mines of the Indian Iron and Steel Company.*

FIG. 10—*Santhal aboriginals at a bazaar near one of the iron and steel centers.*

FIG. 11—*Bazaar scene near the plant of the Tata Iron and Steel Company.*

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choose Indian labor it compares quite favorably with white labor working under similar conditions.

Labor Supervision.

As regards supervision, that of course is another matter, dependent largely upon the fact that the European is the product of several generations familiar with mechanical devices as applied to modern industry. In certain cases it has been more or less satisfactory for the European supervisor to be replaced by an Indian trained in the West, but so far as technical ability is concerned, such replacement will not be generally possible for a good many years, partly because the Indian has had no background of modern industries from which to draw, until very recently, partly because his ancestors had no such opportunity and again because of his temperament, which is philospohical rather than material.

A General Summary.

In no other country are the raw materials necessary for the manufacture of iron and steel so economically located as they are in India. One wonders why this rich field was so long overlooked. In the states of Bihar and Orissa and Central India are known deposits almost inexhaustible in extent of very rich ore, for the most part above a drainage level, not to mention immense deposits of lower grade ores. And further, much of the jungle has been bought roughly prospected. In the same area are deposits of dolomite suitable for flux and sufficiently extensive for present and immediate future needs, while in Assam are whole cliffs of a fine grade of limestone. Very rich deposits of coal are found in these same states; however, the quantity suitable for blast furnace coke is somewhat limited, especially when we consider its use in the smelting of the very large ore deposits. Conservation of the known coal deposits will be necessary and in this connection the recently developed Trent process for cleaning low grade coals should make available the very large deposits of such coal in this area.

In India there is a large active and a very large potential demand for iron and steel. The total steel imports into the country from all foreign sources amounted to 185,000 tons for the year ending March 31, 1921. In addition large quantities of wire and pressed metal products, tin plate, tools and machinery are imported and in consequence of this demand, eight subsidiaries of the Tata Iron & Steel Company are proceeding with their construction at Jamshedpur and several others are contemplated.

Regarding the possible export of steel from India, it is only fair to assume that she will dominate, in the near future, the nearby markets of the Federated Malay States, the Dutch East Indies and the Philippines, and will compete with China and Japan in their own markets, in addition to supplying the demand in the Near East.

This will be possible because of her immense raw material resources, economically located; the comparatively short railway haul, 150 to 200 miles radius of Calcutta; the cheapness and quantity of labor available, aided by modern machinery and the nearness to her foreign markets, compared to any of the countries now producing or liable to produce steel on a large scale.

In view of India's proximity to the Eastern markets, and the high labor cost in European countries and particularly in this country, which will obtain for a very long period of years due to our much higher standard of living (so called), it is difficult to see how the competition of Western industrial nations can interfere to any serious extent with her almost complete control of these markets in the near future.

Eastern Versus Western Civilization.

Once given the impetus, which is already noticeable in the iron and steel industry, it is very improbable that this ancient people, who were enjoying a high state of civilization when the ancestors of their present conquerors were dancing in savage glee around their pagan idols at Stone Henge, will not take full and complete advantage of the resources which nature has so generously given them.

It is to be hoped that India and other Eastern countries will, somehow, avoid in the economic development of their resources which is being forced upon them by the industrialized West, the sordid artificiality of life with which these Western countries have surrounded themselves.

It will, indeed, be a happy result if they are able to combine the best of our material civilization with the ancient ideals and aspirations of the East without sacrificing that simplicity and beauty of life for which there are no counterparts in the West.

CHURN DRILL BLASTING AT LIMESTONE QUARRIES

The churn drill, or well drill, as it is commonly called, has been used very widely in quarry work during recent years, states Oliver Bowles, mineral technologist of the Bureau of Mines. Recent modifications and improvements are described in the catalogue of the various manufacturers. Churn drills may be operated by steam, gasoline, compressed air or electricity. The latter is probably the most convenient and requires the least labor. Heavy blasting in deep churn-drill holes is very commonly employed in limestone quarries, particularly where the product is used as crushed stone or for cement manufacture. The method is less widely used at lime-plant quarries, partly on account of unfavorable quarry conditions, and partly because quarrymen are unfamiliar with the advantages or the method of operation of this type of equipment. Faulty blasting in churn-drill holes has also aroused prejudice on the part of many observers. A few years ago a churn drill was tried in a limestone where clay pockets were numerous and continued many feet below the surface. Unfortunately the drills either penetrated or came in close proximity to the clay pockets or cavities with the results that most of the force of an expensive charge was dissipated, and the rock ledge was scarcely shattered. Churn-drill blasting is now conducted very successfully in this same quarry by giving special attention to the avoidance of clay seams and pockets, but the one glaring example of failure and heavy loss has discouraged the employment of such drills in surrounding quarries. The results of a study of the use of the churn drill at lime-plant quarries is contained in Serial 2424, which may be obtained from the Bureau of Mines, Washington, D. C.

Industrial Furnace Brickwork

Mechanical Questions Involved in the Use of Bricks of Various Shapes and Sizes—Materials in Manufacture—Bonding; Door Arches, Roofs.

By M. H. MAWHINNEY

THE problems which are met with by designers and bricklayers in the construction of industrial furnaces are vastly different from those involved in building construction, and yet it seems that, with the exception of that contained in brickmakers' catalogs, there is practically no published information on the materials and processes used in this work. Professor Trinks' new book on "Heating Furnaces and Annealing Furnaces" contains some valuable information on this phase of the industrial furnace, although the discussion is limited by the more important theory and data on the properties of bricks of different kinds. The purpose of this article, then, is to give some information, although it must be very incomplete, on the purely mechanical question of the use of bricks of different shapes and sizes in the construction of furnaces.

Materials.

The bricks in common use in the steel mills may be first classified with regard to the material from which they are made, and may be listed as follows:

Firebrick. This is the commonest brick in use for furnaces, and is used in all of the shapes and sizes which are mentioned later. Firebricks are made in three grades, depending upon the refractory qualities, and are called first class, second class, and third class firebricks. These grades may be again classified according to the amount of burning which they receive in their manufacture. That is, they are either hard-burned, medium-burned, or soft-burned. In selling first class firebrick, these grades are carefully sorted and sold separately, but in the case of second and third quality brick they are not separated. A hard-burned brick is stronger and more durable than a soft-burned brick, and may be easily recognized by its brownish, burned color and glazed surface.

Silica. Silica bricks are very refractory bricks which are used in furnaces which are kept at uniform temperature. The coefficient of expansion is high, and silica bricks with spall and crack with alternate heating and cooling, or with exposure to water. Practically the same shapes of silica bricks and fireclay bricks are kept in stock in the bricksheds of a steel mill.

Magnesite, Carborundum, Asbestos Bricks, etc. These are highly refractory and expensive bricks which are used in limited quantities in certain high temperature portions of furnaces. These bricks are generally found only in a small variety of shapes and sizes, although other shapes and sizes can be purchased.

Red Brick and River Brick. These are used for outside walls and other parts of furnaces which are exposed to but very little heat. River brick is of higher refractory quality than red brick.

All of these bricks, with the exception of red bricks, the standard size of which is 8¾x4¼x2¾ in., are made in various standard shapes and sizes, although only in the case of firebrick and silica brick are any considerable number of the manufactured shapes and sizes kept in stock in large quantities.

The specifications of the different shapes may be obtained from brickmakers' catalogs, but a list of those in common use, together with their chief uses, is given. The shapes are illustrated in Fig. 1.

9-in. Square Brick, or Straight. 9x4½x2½ in. This is the commonest brick in use in all parts of a furnace. When laid on edge they are said to form a "rowlock" course (horizontal layer of bricks), while laying them on their farce forms a "flat" course.

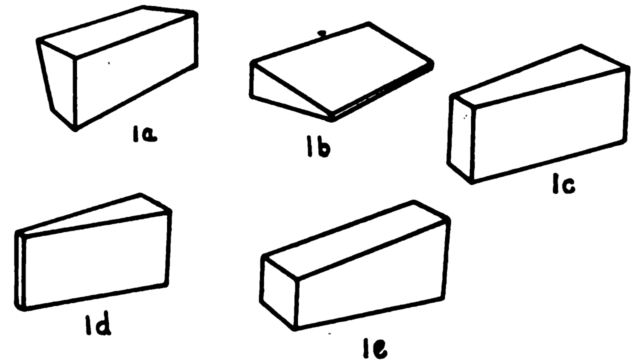

Fig. 1—Standard shapes used in furnace construction.

Side Arch. (Fig. 1a.) No. 1, 9x4½x(2½—2⅛) in. No. 2, 9x4½x(2½—1¾) in.

These dimensions indicate that the bricks are tapered from 2½ in. thickness on one side to either 2⅛ or 1¾ in. on the other, depending upon the number stamped upon the brick. It must be understood that the arch brick and wedge brick are not tapered symmetrically, but in each case one surface is square with the edges, while the other surface is inclined as shown in Fig. 1. Side-arch bricks are used principally in building 4½-in. arches over doors, but, like all shapes, they are used wherever they may be adapted advantageously.

Featheredge. (Fig. 1b.) 9x4½x(2½—⅛) in. In this case, the brick tapers from 2½ in. thick on one side to ⅛ in. thick, or practically an edge, on the other. They are used as skewbacks (arch abutments) or in places where a triangular space is to be filled.

End Wedge. (Fig. 1c.) No. 1, 9x4½x(2½—1⅞) in. No. 2, 9x4½x(2½—1½) in. In this case, the taper is along the length of the brick, one end being 2½ in. thick in each case, while the other end is thinner, depending upon the number of the brick. End wedges are used chiefly for making arches and roofs which are 9 in. thick.

No. 3 Neck Brick. (Fig. 1d.) 9x4½x(2½—⅝) in. This brick is similar to an end wedge, but tapers to only ⅝ in. on the thin end.

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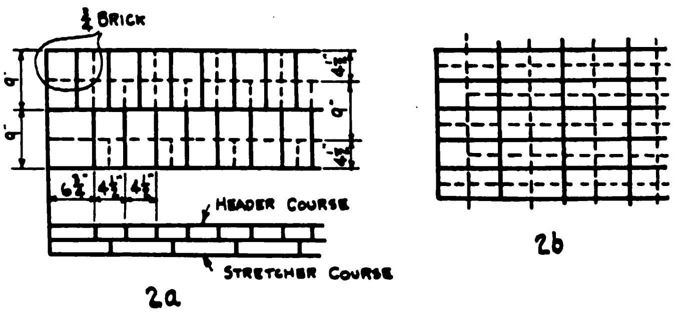
Splits. No. 1, 9x4½x1¼ in. No. 2, 9x4½x2 in. These bricks are used with 9-in. squares to make walls of any desired height without cutting brick.

Large 9-in. Brick. 9x6¾x2½ in. Large 9-in. brick, sometimes called seven-by-nines, are used chiefly for bonding walls, as shown in Fig. 2a.

Large 9-in. Wedge. 9x6¾x(2½—2⅛) in. These wedges are used in bonding large 9-in. arched roofs.

Key Brick, or Bullheaders. (Fig. 1e.) 9x(4½—4)x 2½ in. In this case, the thickness of the brick is constant, but it is wider at one end than at the other. Laid in flat courses, bullheaders may be used to form a bellied wall. They may also be used in the construction of a sloped arch.

Tile. Firebrick and silica brick are also manufactured in the form of tile. There are a great many different kinds of tile, but the following are some of the more important varieties: 13½x6x2½ in., used in 13½-in. walls. 13½x9x2, 2½, 3 and 4½ in. thick. Also made in the form of side arch and end wedge for use in large roof arches. 9 in. wide by 4½ in. thick by 16, 18, 22½ and 27½ in. long. Used in place of arches in doors or openings in walls, or for openings in a roof. See Fig. 5.



2a

2b

Fig. 2—Method of bonding used in wall construction.

Skewback Tile. These are large tiles especially designed to fit iron abutments and support an arch They are also made in the form of a double tile whose parts fit a watercooled pipe and support a suspended arch. See Fig. 4.

Pipe Tile. Pipe tiles are grooved tiles which are used to cap the piers in a continuous furnace and carry the water cooled skid pipes.

Except in the case of experimental work, the bricklaying in a steel mill is practically standard. That is, the shapes which are required in each different furnace are the same each time that the furnace is rebuilt. For this reason, all of the shapes used are kept in stock, because the cutting by hand of even a few shapes is a slow and expensive task. However, if necessary, the skilled bricklayer can cut practically any shape required from a square brick or tile.

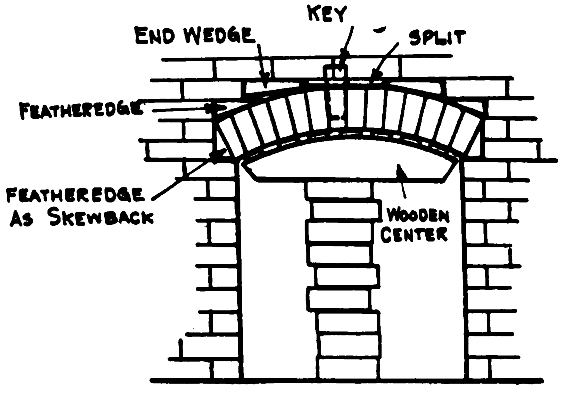


Fig. 3—Typical sprung door arch.

With this brief outline of the bricks used, let us turn to the chief problems met in the construction of furnace brickwork.

Bonding.

Bond in brickwork means a tie or link, obtained by so overlapping the bricks that heat or slag penetrating between two brick anywhere in a course of bricks will not strike a joint in the next course. This is accomplished by the use of "headers" and "stretchers," a header being a brick which is laid so that its length is perpendicular to the face of the wall, and a stretcher being a brick laid with its length parallel to the face of the wall. Fig. 2 illustrates two of the common bonds used in furnace construction, the heavy lines denoting one course and the dotted lines the alternate course. Fig. 2a shows a straight 18-in. wall. By "three-quarter" brick is meant a straight brick which is cut to any length more than one-half the normal length and less than full length. It will be observed that at some points in this figure, the solid lines and the dotted lines coincide, which means that at these points the bricks are not properly bonded in a vertical direction. However, for a wall this is not serious, because bonding horizontally between the faces is the main thing. In the case of a furnace bottom, however, the conditions are reversed; the brickwork must be bonded up and down, while the lateral bonding is not necessary. Fig. 2b shows the common method of bonding a furnace bottom.

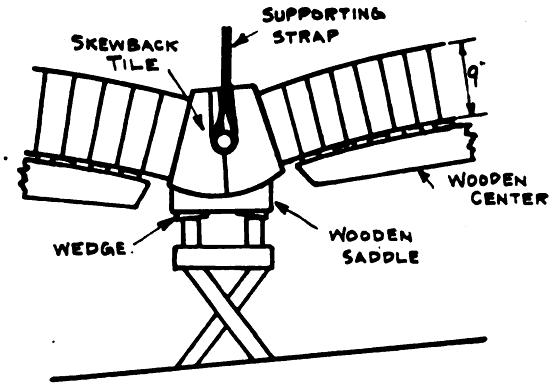


Fig. 4—Illustrating the use of skewbacks in suspended arch construction.

Door Arches.

In some cases, a large tile is used over a door, but in the majority of cases an arch is laid up of brick as shown in Fig. 3. To do this, the wall is first run up to the height of the door and skewbacks are set in on either side. These skewbacks sometimes consists of specially made bricks called skewback bricks, but more generally featheredge bricks are used in the construction of the skewbacks. A wooden center consisting of curved ribs covered with light lagging is then supported on bricks in the opening and adjusted. Various combinations of square bricks, No. 1 and No. 2 sidearch or end wedge (depending upon the thickness of arch desired) are then laid up dry, that is, without clay, until a good fitting arch is obtained. These are taken out and laid up in clay from the two sides toward the center, the last brick to be put in being a No. 2 arch or wedge brick at the crown of the arch, so that by driving this key brick in with a sledge hammer, a good strong arch is obtained. In running the wall up over the arch, side arch brick, featheredges and split bricks are used to fill in over the top, as shown in the illustration.

Roofs.

A most interesting construction, and one which embodies all the principles of roof arch construction, is that of the suspended arhes which are used in continuous furnaces. These arches are generally four in number, and rest on skewback tile which fit over watercooled pipes hung by straps from the ironwork of the furnace binding. Fig. 4 shows the method of construction. The skewback tiles are made in pairs to fit the pipes, and are numbered to avoid confusion of corresponding pairs. Wooden frames are first set up under the pipes to carry the wooden saddles which support the skewback tiles. These saddles are adjusted by means of wedges as shown, and the tiles are set up all the way along under the pipes. A large wooden center is then set up between ach set of pipes, and the arches are laid up with No. 1 and No. 2 end wedges and squares from the skewbacks toward the top, a row of end wedges, or keys, being left at the crown and pounded in with a sledge hammer to insure a tight job. A row of bricks from one side of an arch to the other is known as a "ring." If adjacent rings are toothed into each other, the arch is bonded, but if each ring is distinct and separate clear across, the arch is said to be laid up in rings.

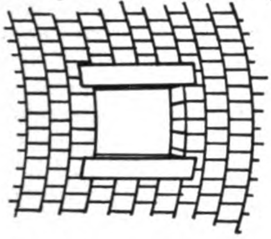


Fig. 5—Tiles used in door construction.

In the case of a silica roof, expansion is a serious factor in brickwork construction. Expansion in the direction of the arch of the roof is of course taken up by the rise of the arch on heating or by tie rods equipped with springs, all of which is very completely discussed in Professor Trinks' book. Along the length of the furnace, however, the situation is different and allowance must be made for expansion, especially on large roof. If the arch is laid up in rings, strips of wood about ⅛ in. thick are laid between rings and spaced about three rings apart. These strips burn out on heating up, and the brickwork adjusts itself without damage. In the case of a bonded roof, this method is impossible, and a space is left at the ends to allow for expansion. A firebrick roof requires no allowance, as the expansion is very slight. The use of wooden strips is also very common in the paving of furnace floors with magnesite bricks.

It is often desired to construct a flue opening in an arched roof. This is accomplished by using tiles as shown in Fig. 5. These tiles prevent the thrust of the arch from caving the roof in at the point where it is weakened by the opening.

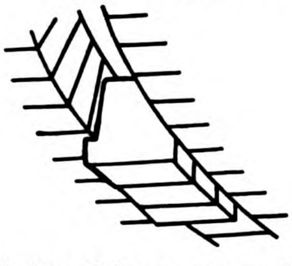


Fig. 6—Hand chipping of tiles to prevent them from falling through opening.

Repairs.

Furnace repairs are of two kinds; the so-called hot jobs, where the repairs must be made in a hurry without shutting down the furnace, and the cases where the furnaces are partially or completely rebuilt or remodeled.

Of the hot jobs, the patching of a roof offers the most difficulty. A few bricks or, in some cases, several complete rings may fall into the furnace and have to be replaced immediately without interrupting the operation of the furnace. To do this, bricks are cut by hand with a lug to prevent them from falling through the opening as shown in Fig. 6, and are set by means of tongs from the platforms or runways over the furnace. When the opening is filled, the patch is plastered with stiff fireclay and will last until the week end, when the furnace can be shut down for general repairs.

When a furnace is rebuilt, the brickwork is dug out with a sledge hammer and chisel, and the majority of the bricks are removed in good condition, except that they are burned and spalled in varying degrees. These bricks are always put back into the furnace in some place where they will not be exposed to great heat, but will save the using of new bricks of lower refractory grade. Most often they are used in backing up between the inside brickwork and the red brick shell of the furnace walls.

This covers in a general way the chief points of interest in the construction of furnace brickwork, although, as stated in the beginning, the information is brief and incomplete. However, it furnishes the foundation upon which designers and students may base intelligent inquiries for further information, as it gives definitions of bricklaying terms and a general idea of the methods used in brickwork construction.

W. M. CORSE ON "MANUFACTURE AND PROPERTIES OF NICKEL"

The paper by Mr. Corse, at the December meeting of the Chemical Society, was an exceptionally good one, presenting technical information of great value to the chemist and metallurgist in a style so lucid and interesting as to hold the attention even of the layman.

The speaker alluded to the growing tendency to discuss metals as if endowed with human attributes as evidenced in speaking of their diseases, fatigue, life, affinities, natural and artificial coloring, etc. He traced the history of the nickel industry, giving a brief chronology, and pointing out as obstacles to rapid development, the lack of a process for extraction and the absence of a market for the product. Dealing mainly with metallurgy, Mr. Corse showed that commercial development has been mainly in this field while investigation of the chemistry of nickel has lagged far behind—so much so that, today, many of the standard reference and text-books contain fallacies and inaccuracies. The speaker indicated an enormous range of industrial applications and gave figures showing to what extent each of these is a consumer of nickel.

We hope that other Sections of the Society may have an opportunity of hearing Mr. Corse's paper and that eventually it will be published in full.

The paper was supplemented by several reels of moving pictures illustrating actual metallurgical processes, the pictures being explained and amplified by Mr. McKay of Mellon Institute of Industrial Research, who is very thoroughly informed in this particular field.

Use of Magnetic Ore in the Blast Furnace[*]

Notes on the Use of Fine Unsintered, Raw, Lumpy and Fine Magnetic Ore Which Has Been Sintered with Some Comment as to Design and Difficulties Encountered—Particular Reference Made to the Ores of Eastern Pennsylvania and the Adirondack Region.

By G. P. PILLING[*]

THE use of magnetic ore in the blast furnace is a subject of increasing importance. The end of the deposits of lake ore is in sight, although not imminent, and unless some new field is discovered, the use of magnetites will be an increasing factor in the iron production of the country. Enormous deposits of magnetic ore in the country that have been practically untouched contain ore of sufficient richness and purity to prolong materially our ore supply without extensive importation of foreign ores.

Magnetic ores can be divided into three general classes: Fine unsintered, or raw ore; raw lumpy ore; fine ore that has been sintered.

Fine Unsintered Ore.

Typical analysis and screen test of this class of ore from the Adirondack region is as follows:

	Per Cent	Screen Test	Per Cent
Fe	58.00	Remaining on 4 mesh	7.50
SiO_2	7.50	Through 4 on 8 mesh	13.75
Al_2O_3	1.60	8 on 10 mesh	3.75
Bases	2.77	10 on 20 mesh	22.50
P	1.00	20 on 40 mesh	27.50
Mn	0.13	40 on 60 mesh	2.50
S	Trace	60 on 80 mesh	10.00
		80 on 100 mesh	2.50
		100 mesh	10.00
			100.00

OTHER ANALYSES AT 212° F.

		Per Cent			Per Cent
Fe		63.00	Fe		63.80
SiO_2		6.00	SiO_2		8.20
Al_2O_3		1.33	Al_2O_3		1.63
Bases		3.50	Bases		0.90
CaO	3.08		CaO	0.50	
MgO	0.43		MgO	0.40	
P		0.70	P		0.021
Mn		0.03	Mn		0.03
S		Trace	S		Trace
Titanium		Trace	Titanium		1.05

As none of these ores contain any appreciable amount of manganese, it is necessary to add to the ore mixture, material containing this element. The material is usually a high manganese ore from the lake region; very high imported manganese ore; or, where it is available, the cinder from a furnace producing ferromanganese.

The successful use of fine magnetic ore in the blast furnace depends on a number of factors, all of which must be carefully determined for each individual case. However, there are a number of basic principles, which are briefly discussed here.

Correct Furnace Design.

The first thing to consider when designing a furnace is that the reduction of this ore requires from 3 to 4 hr. longer than an equal amount of hematite. The working volume above the tuyeres must therefore be larger. It has been found that approximately 4,500 cu. ft. working volume above the tuyeres is required for each 100 tons of iron produced in 24 hours.

The next thing to be considered is the design of the bosh. Unless every precaution is taken, the fine magnetic ores tend to work in a high zone of fusion in the furnace, thereby raising the ratio of direct to indirect reduction, which of course tends to high fuel and poor furnace results. The height of the bosh above the center lines of the tuyeres must, therefore, be kept as low as possible, not over 12 ft. and preferably lower than this. In a new furnace, the bosh angle should be not less than 78 deg., but if an old plant is being remodeled, the bosh should be kept low, even if necessary to flatten it somewhat.

The next point for consideration is the batter of the inwall. This is governed by three considerations: (1) These fine magnetic ores, in their passage through the furnace, are practically free from swelling due to carbon deposition. (2) These ores, when distributed from the bell on to the stock, will travel down through the furnace in a practically straight line and will not move laterally to any extent. (3) The tendency is, at all times, for the ore to run ahead of the rest of the charge, thereby arriving at the zone of fusion in an unreduced state. The batter of the inwall should therefore be between 0.55 and 0.7 in. per ft. Anything greater than this allows the charge to loosen up too rapidly, thereby permitting the ore to run ahead; the ore has a tendency to work its way down through the center of the charge in a column approximately the diameter of the stock line, leaving an annular ring of open material against the walls of the furnace. Because of the difficulty of distributing an even layer of ore in the furnace, the stock line must not be too large: neither must it be too small or the flue-dust loss will be excessive. The stock-line diameter, however, is more or less fixed, being determined by the other dimensions of the furnace.

Stock Distribution.

One of the greatest difficulties met with in working fine magnetic ores is the correct stock distribution. It is necessary to procure almost theoretically perfect distribution of the ore from the bell on to the stock, for after the ore has been placed on the top of the charge, it has practically no lateral movement, i.e., the ore will not work from the outside of the furnace toward the center or vice versa. This means that the size of the coke unit, which necessarily governs the size of the ore unit, must be carefully studied and regulated; it is considerably larger than the coke unit used with hematite ores. For instance, a furnace having a stockline diameter of 12 ft. should have a coke unit of not less than 7000 lb. and a furnace with a stock-line of 15 ft. should have a coke unit of about 10,000 lb. It has been found that the best results are obtained by filling the ore and coke separately from the large bell into the furnace. The typical round for a furnace with a 12-ft. stock-line on this class of ores would be as follows: Place 7200 lb. of coke and all the limestone on the bell and lower into furnace; place all the ore on the bell and lower into furnace. The mixed or stratified charge does not seem to give good results. The reason for this round is that to distribute the ore evenly over the surface of the proceeding charge, advantage must be taken of the rebound of the ore from the walls to place the correct proportion of ore at the center of the furnace.

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[*] A paper prepared for the February meeting of the American Institute of Mining and Metallurgical Engineers, in New York.

[†] Philadelphia, Pa.

It is common practice, when using fine magnetic ores, to use a 45 deg. angle bell and not over 2 ft. clearance between the bell and the stock line.

Time Required for Reduction or Rate of Driving.

On account of the hard, dense nature of fine magnetic ore, it is necessary to allow not less than 11 hr. and preferably 12 to 14 hr. for reduction. If the furnace is driven faster than this, in from 48 to 60 hr., it will start to work cold and unreduced ore will appear in front of the tuyeres, the slag will become black with small particles of ore floating on the top, the silicon in the iron will be lowered, and the sulphur in the iron will rise very rapidly.

Air Distribution.

When working these fine magnetic ores, care must be taken not to have the tuyere area too large. At a number of plants, the best work is being done with about 130 to 150 cu. ft. of air per minute engine displacement per square inch of tuyere area. In one case, 30,000 cu. ft. of air per minute was blown through 12 5½ in. tuyeres, but the results, both as to tonnage and fuel consumption, were far from satisfactory. After the tuyeres were changed to 4½ in. the fuel consumption was reduced by about 100 to 150 lb. per ton of iron, and the product increased 20 tons per day.

It is not practicable to blow as much air when smelting fine magnetic ores as when smelting an equivalent hematite ore. If the furnace is over-blown, the zone of fusion tends to rise, thereby increasing the percentage of direct reduction, the ore comes through in an unreduced state, and the top heats immediately rise above the level for most economical operation.

Flux.

Most furnaces using these magnetic ores use a calcite stone when it is available, although very good work is being done with a low magnesia dolomite. All the stone used for flux should be crushed to not larger than 4 in. and all fines under ¾ in. screened out.

Selection of Coke.

It is very important, when working magnetic ores, as well as all other ores, that the coke used will burn freely and quickly at the tuyeres, thereby keeping the zone of fusion as low as possible; at the same time it should be dense enough so that there will not be an excess of loss by solution and direct reduction by carbon. Ordinarily, a coke of fairly high sulphur content can be used, inasmuch as practically none of the magnetic concentrates used in the raw state carry any appreciable percentage of sulphur.

Furnace Operation and Results.

The fuel consumption, when using 100 per cent of this grade of ore, is uniformly higher than that of hematite or sintered magnetic ore. A fair average of the work of a furnace using 100 per cent of this fine magnetic ore will probably be about as follows:

FOUNDRY IRON

	Ped Ton Iron
Silicon, 2.25 to 2.75%	2400 to 2500 lb. of coke
Silicon, 1.75 to 2.25%	2250 to 2300 lb. of coke

BASIC

Silicon, under 1.00%	2000 to 2100 lb. of coke

The iron produced is usually quite low in sulphur. If it is necessary to produce a large tonnage of high silicon iron, the best results are obtained by using a small percentage of siliceous hematite ore in the mixture, as it is extremely difficult to produce high silicon iron using 100 per cent of fine magnetic ore. Gravel or other siliceous material may be used but do not give up their silica as easily for reduction into the iron.

Slags.

On account of the absence of sulphur in these ores, it is possible to run uniformly high acids in the slag. Some plants are being successfully operated on an average of 50 to 51 per cent total acids in the slag with the sulphur in the iron well under 0.030 per cent.

Furnace Irregularities.

Furnace operation on this class of ore is practically entirely free from the troubles resulting from hanging and slipping, such as are encountered when working hematites. However, the furnace appears to be extremely sensitive to every minor change in stove heat, atmospheric condition, and particularly any irregularity of stock distribution. Very careful supervision is therefore necessary, as a very slight irregularity in the furnace operation is accompanied by serious trouble, which appears with unusual swiftness and practically without warning.

Conclusion.

Typical results of a small furnace using 100 per cent fine magnetic concentrates are as follows:

FURNACE LINES

Hearth diameter, feet	12
Bosh diameter, feet	16
Stock-line diameter, feet	12
Height, center line of notch to top platform, feet	80
Inwall batter, inch per foot	0.6
Bell diameter, feet	8
Bell angle, degrees	45

IRON ANALYSIS

Silicon, per cent	1.75 to 2.25
Daily product, tons	210 to 220
Coke consumption, pounds per ton of iron	2350
Air blown, cubic feet per minute	19,000
Flue dust produced, tons per day	15
Slag volume (calculated) pounds per ton of iron	1100
Average stove heats, degrees	1100
Average top heat, degrees	450

Raw Lumpy Magnetic Ore.

The writer is not familiar with any furnaces operating on 100 per cent raw lumpy magnetic and trusts that this practice will be brought out in the discussion of this paper. The plant here described is operating in the following ore mixture:

20 per cent ore A, lumpy magnetic (magnetic ore).

20 per cent ore B. magnetic concentrates (magnetic ore).

40 per cent Old Range (Lake ore).

20 per cent Central Western (Lake ore).

	Ore A %	Ore B %	Old Range %	Central Western (Natural) %
Fe	56.55	51.85	62.65	49.96
SiO_2	11.82	4.29	10.62	6.03
Al_2O_3	1.59	1.19	1.26	2.33
CaO	2.28	0.15	1.18	0.32
MgO	1.25	0.54	0.51	0.22
P	0.028	0.066	0.094	0.073
Mn	0.09	0.40	0.03	0.89
S	0.694	0.009	....	0.011
Ignition loss	0.659	3.83	....	5.87
Moisture	1.35	15.00	....	12.50

SCREEN TESTS

	Ore A Per Cent	Ore B Per Cent
Remaining on 4 mesh	7.40	7.50
Through 4 on 10 mesh	9.03	13.75
Through 10 on 20 mesh	7.03	3.75
Through 20 on 30 mesh	1.55	22.50
Through 30 on 40 mesh	4.60	27.50
Through 40 on 60 mesh	2.61	2.50
Through 60 on 80 mesh	2.86	10.00
Through 80 on 100 mesh	0.11	2.50
Through 100 mesh	2.29	10.00
		100.00

The average iron in the above mixture is 53 per cent.

Furnace Design.

Inasmuch as these lumpy magnetic ores are used with a large percentage of hematite ores, the furnace design is naturally a compromise. The inwall batter is made slightly larger than when using 100 per cent magnetic ores, to allow for the swelling action of the hematite ore. Typical lines for a large furnace using the above ore mixture are as follows:

Hearth diameter	18 ft.	5 in.
Bosh diameter	22 ft.	0 in.
Bosh angle	82°	2′
Stock-line diameter	16 ft.	6 in.
Height of bosh	10 ft.	11 in.
Inwall batter	0.75 in. per ft.	
Bell diameter	12 ft.	
Bell angle	45°	
Total height of furnace	93 ft.	6¼ in.
Height of furnace from center line of iron notch to top platform	91 ft.	2¼ in.

Stock Distribution.

The problem of stock distribution, when using lumpy magnetic ores mixed with hematite ores, is not so difficult as with 100 per cent fine magnetic concentrates, for these lumpy magnetic ores do not show the same tendency to run ahead in the furnace, particularly when used with a large percentage of finer hematites. As with the finer magnetic concentrates, however, the ore and the coke should be lowered into the furnace separately from the large bell. A typical round of the furnace under discussion is as follows: Place 10,000 lb. of coke on large bell and lower same into the furnace. Place 16,000 lb, of ore and 4400 lb. of limestone on large bell and lower same into the furnace. The mixed or stratified charge does not seem to give good results. It is also the best practice, when using these lumpy magnetic ores, to use a 45 deg. angle bell and approximately 2 ft. clearance between the bell and the stock line

Time Required for Reduction or Rate of Device.

On account of their hard dense nature, these lumpy magnetic ores require as long or longer for reduction in the furnace as the fine magnetic concentrates; from 12 to 14 hr. are required for thorough reduction. This means that the advantage of the rapid driving of hematite ores is lost and the furnace must be driven at a rate that will give thorough reduction of the hard ore. If the furnace is driven faster than this, the ore comes down to the zone of fusion unprepared, and raw ore appears in front of the tuyeres, resulting in a cold hearth and off-grade iron.

Air Distribution.

The same practice holds good for air distribution and tuyere area on the lumpy magnetic ores as on the fine magnetic ores, although good work is being done with a somewhat lower wind velocity through the tuyeres than on fine magnetic concentrates. The average seems to be about 130 cu. ft. of air per minute engine displacement per square inch of tuyere area. On this furnace with a hearth diameter of 18 ft. 6 in. from 38,000 to 40,000 cu. ft. of air per minute engine displacement, corrected to 2 deg. F., are blown through ten 6 by 12 in. tuyeres. About 5 to 10 per cent less air is required for these lumpy ores when an equivalent hematite ore is used. If the furnace is overblown, the zone of fusion tends to rise, thereby increasing the percentage of direct reduction; the ore comes down in an unreduced state and the top heats immediately rise above the level for most economical operation.

Furnace Operation and Results.

The fuel consumption, when using the ore mixture given here, is uniformly higher than when using hematite ore or sintered magnetic ore and somewhat higher than when using fine magnetic concentrates. Using only 20 per cent lumpy and 20 per cent fine magnetites and making iron with 1.75 to 2.75 per cent silicon, requires 2300 lb. of coke per ton of pig iron; this is with 12 per cent scrap in the mixture. If the percentage of hard lumpy ore in the mixture is increased from 20 to 50 per cent, the fuel consumption is increased about 10 to 20 per cent and the tonnage is lowered about 10 to 20 per cent.

Slag.

Typical slag analysis of a furnace running on these ores is: Silica 35 per cent, alumina 13 per cent. The slag volume carried is 1300 lb. per ton of pig iron.

Furnace Irregularities.

Furnace operation when using a large percentage of lumpy magnetic ores is practically entirely free from the troubles resulting from hanging and slipping, such as are encountered when working 100 per cent hematites. The furnace does not seem to be nearly so sensitive to minor changes as when using 100 per cent fine magnetic ores, although it is extremely sensitive to any change or irregularity in stock distribution.

Fine Magnetic Ore Which Has Been Sintered.

There is no furnace, as far as is known at the present time, operating on 100 per cent sintered magnetic ore. The closest approach to it is a small furnace working an ore burden of 80 to 85 per cent sintered fine magnetic ore, 10 to 15 per cent mixed puddle and heating cinder, and 5 per cent hematite ore. The typical analysis of the sintered magnetic ore is: Iron 55 per cent, silica 10.4 per cent, alumina 1.69 per cent, bases 6.50 per cent, phosphorus 0.075 per cent, manganese

0.18 per cent, sulphur 0.18 per cent. No screen test is available, but the average would probably be from lumps the size of a man's two fists down to ⅛ in.

Preparation of Ore.

The magnetic ore under discussion (Eastern Pennsylvania), as mined, contains about 53 per cent of iron and 3 per cent of sulphur. The ore is then crushed by jaw crushers and rolls to pass through a ⅜ in. round hole. It is then mixed in a pug mill, with flue dust or fine coal, and sintered on a Dwight-Lloyd sintering machine. The resulting sinter contains about 0.18 per cent sulphur and physically is in ideal shape for blast-furnace use. The sinter is extremely open and porous and therefore exposes a maximum surface to the blast furnaces gases for reduction. Also a considerable percentage of the magnetite has been reduced to hematite by the sintering process.

Furnace Design.

The furnace to be discussed has the following lines:

Hearth diameter	12 ft. 0 in.
Bosh diameter	17 ft. 1 in.
Bosh angle	76° 30'
Bosh height	12 ft. 1¼ in.
Stock-line diameter	12 ft.
Bell diameter	8 ft.
Bell angle	54°
Inwall batter	0.78 in. per ft.
Total height	75 ft. 0 in.
Number of tuyeres	12

The bosh angle is rather flatter than for most modern furnaces, as this is a remodeled furnace; it was the steepest bosh that could be procured unless the entire lower part of the furnace was rebuilt.

The inwall batter is greater than for either raw fine magnetic concentrates or lumpy magnetic ore. It has been found that sintered magnetic ore apparently works in the furnace in a manner about half way between raw magnetic concentrates and hematite ore, and therefore allowance must be made for this in the furnace design. That these sintered magnetic concentrates will not work successfully on a smaller inwall batter than this has not been demonstrated; although three furnaces have been built to use this class ore with an inwall batter of less than 0.6 in. to the foot, none of these had been operated when this was written.

Stock Distribution.

The problem of stock distribution with sintered magnetic concentrates does not seem to be as difficult as when lumpy or fine unsintered magnetic ore is used, although the basic principles are the same. Owing to the large, lumpy coarse nature of the sintered ore, there is no tendency for it to run ahead in the furnace. But practice has shown that best results are obtained, as with the other two classes of ore, by lowering the ore and the coke into the furnace separately. The typical round for the furnace under discussion is: Place 8000 lb. coke and all the limestone on large bell and lower into furnace; place all the ore on large bell and lower into furnace. The mixed or stratified charge does not seem to give quite as good results, although it can be used, if necessary or desirable.

Time Required for Reduction, or Rate of Driving.

One of the greatest advantages of using sintered magnetic ore is that the rate of driving can be materially increased. Because of the open nature of the sintered ore, a large surface is exposed to the action of the blast furnace gases and reduction proceeds rapidly. It is perfectly feasible to procure thorough reduction of sintered magnetic ore in the furnace in about 9 to 10 hr., which is about 3.5 hr. less than the time required for raw magnetic ore. This, of course, is a big advantage and increases the production to a considerable extent.

Air Distribution.

As for the raw magnetic ores, about 150 cu. ft. per min, engine displacement of air per square inch of tuyere area give the best results. The flue-dust losses, on sintered ore, are very low so that it is possible to blow more air than with fine magnetic concentrates. This increased volume of air does not make the furnace drive too fast for proper reduction, inasmuch as the time required for reduction is much less.

Furnace Operation.

Sintered magnetic ore can be successfully mixed in any proportion with hematite ores and good results obtained. Mixtures have been used ranging from 20 per cent sintered ore and 80 per cent hematite to 80 per cent sintered ore and 20 per cent hematite. The fuel required per ton of pig iron, when using a large percentage of sintered magnetic ore, is much lower than when using raw magnetic ore. Results seem to indicate that iron can be made with sintered ore with approximately 150 to 250 lb. less coke per ton of pig iron than when using raw magnetic ore. The furnace operation is exceedingly smooth and regular; the blast pressure uniformly low and even; and the furnace settles regularly with practically no trouble from hanging and sticking. Very high blast heats can be carried without difficulty, thereby effecting further saving in fuel.

Slag.

Because of the fairly high sulphur content of the sintered ore, which comprise 85 per cent of the mixture, it is necessary to carry a large slag volume. About 1500 to 1600 lb. of slag per ton of pig iron is required. If the total acids in the slag rise much above 48 per cent, some difficulty is encountered in eliminating the sulphur. This large slag volume, of course, is not required when using an ore with no sulphur content.

Furnace Irregularities.

A furnace operating on a large percentage of sintered magnetic concentrates seems to be freer from furnace troubles and irregularities than any other kind of ore. There is practically no trouble from hanging or sticking and the furnace does not seem to be sensitive to changes in atmospheric conditions or other irregularities; in fact, it is unusual to have any trouble, and there have been occasions when the furnace has run for months with no irregularity or trouble of any kind whatever developing.

Conclusions.

From the results obtained on this furnace using this large percentage of sintered magnetic ore, it has been demonstrated that the fuel consumption is from 150 to 300 lb. lower and the product about 30 tons per day higher than could be expected from an equivalent size furnace using the same proportion of either raw fine magnetic concentrates or raw lumpy magnetic ore. The operation of the furnace is greatly simplified and the results obtained are most satisfactory from every standpoint.

The results obtained at this furnace on basic iron during the month of February, 1922, are as follows. The furnace was blown in December 26, 1921, and operated on foundry iron until February 1, when it was turned on to basic. The burden was:

BURDEN

Coke	8,000 lb.
Ore	14,500 lb.
Stone	5,300 lb.
Borings, turnings; of ore weight	15%

OTHER DATA

Air Per minute, average	20,750 cu. ft.
Stove heats, average	1,300° F.
Blast pressure, average	13 lb.
Top heats, average	400° F.

IRON ANALYSIS

	Per Cent
Silicon, average	0.80
Sulphur, average	0.032
Phosphorus, average	0.50
Manganese, average	1.60

SLAG ANALYSIS

	Per Cent
Silica	34
Alumina	12.50

The furnace averaged 266 tons of iron per day on 1832 lb. of coke per ton of pig iron. The 1832 lb. of coke per ton was based on railroad weights, which includes all the fine coke screened out at the bins, so that the actual fuel consumption was somewhat lower. The results for the last two weeks of February after the furnace had settled down on to basic iron were: Average production per day 287.7 tons of iron on 1719 lb. of coke per ton of pig iron.

Grade	Start Date	Stop Date	Average Tons	Average Coke	Mixtures	Per Cent
1X and 2X	1/ 1/22	2/ 3/22	201	2220	Sinter	75
					Lake	10
					Puddle	15
					Turnings	10
Basic	2/ 4/22	3/ 8/22	274	1800	Sinter	80
					Lake	5
					Puddle	5
					Heating	10
					Scrap	15
Malleable	3/ 9/22	3/14/22	254	2040	Sinter	80
					Lake	20
					Turnings	10
1X and 2X	3/15/22	4/12/22	227	2120	Sinter	82
					Lake	12
					Puddle	6
					Turnings	10
Malleable	4/13/22	4/16/22	234	2000	Sinter	80
					Lake	5
					Heating	15
					Turnings	10
2 Plain	4/17/22	4/27/22	233	2080	Sinter	82
					Lake	12
					Puddle	6
					Turnings	10
Basic	4/28/22	5/ 5/22	257	1876	Sinter	82
					Heating	15
					Lake	3
					Turnings	15

Summary.

Of the three ores here mentioned, the least desirable is the lumpy or coarse magnetic ore. The raw fine magnetic ore is slightly better, provided the furnace design is correct and careful study is given to its use. The operating difficulties with the fine unsintered magnetic ore are very great, as any small change or irregularity in furnace operation quickly results in serious trouble, so that constant attention is required for its successful use.

The sintered fine magnetic ores are by far the best of the three for blast-furnace use. The effect of sintering is to do away with furnace trouble and irregularity almost entirely. It permits faster driving of the furnace and results in considerably lower fuel consumption. This is somewhat offset by the cost of sintering—about 80 cents to $1.00 per ton of sinter. Of course, where the raw ore contains an appreciable amount of sulphur, sintering, roasting or nodulizing is absolutely necessary before the ore can be used in the furnace.

In some cases, very poor results have been obtained by attempting to use a mixture of raw magnetic ore and hematite ore; these were probably due to the fact that this mixture was used on furnaces designed to operate on all-hematite ore. In addition, in operating the furnace, the point was probably overlooked that it was necessary to handle the operation as though the entire mixture was magnetic ore, allowing the hematite ore to take care of itself. This means that the furnace must be driven at a rate that will allow plenty of time for the reduction of the magnetic ore, even though the hematite does not require so long.

The entire problem of working magnetic ore in any form is one that requires a great deal of study and care to bring all the elements into thorough accord.

Great credit is due all the furnace operators for their open-minded policy of exchanging information and results, thereby pooling their common knowledge for the benefit of all concerned.

SERVICE INVOLVED IN NATURAL GAS DISTRIBUTION

The distribution of natural gas involves the rendering of a service as well as the selling of a commodity, because the distributor is expected not only to furnish gas, but also to deliver the quantity the consumer wishes whenever he demands it, states R. A. Cattell, natural-gas engineer of the Bureau of Mines, in Technical Paper 325, "Natural gas manual for the home," just issued. It is not always possible to fulfill expectations entirely since no more gas can be distributed than is yielded by the wells, and the company can only serve within the limits of supply. The demand for natural gas for household use is extremely variable—for example, the quantity of gas used by domestic consumers in January may be six or seven times the quantity used by these consumers in August—and if good service is to be rendered at all time, the capacity of the wells and the transmission and distribution system must be sufficient to meet the maximum demand. This means that a natural-gas system largely dependent upon domestic sales must work far below its capacity throughout most of the year. The cost of supplying natural gas includes the expense of standing ready to serve in addition to the cost of the gas, and payment for natural gas should be on a basis that recognizes both the service and the commodity features and provides that each consumer shall carry his fair share of the burden of cost.

Recent Electric Furnace Developments

Rapid Recovery from the Stagnation Experienced During the Previous Year—Gray-Iron Foundries Slow to Realize the Advantages of Electric Melting of Low Phosphorus Irons.

By EDWARD T. MOORE[*]

THE rapid development of any process or apparatus is quite generally accelerated by an increasing demand for it, and this has been particularly true of the electric furnace since its inception over 40 years ago. The demand for tool and alloy steels from the electric furnace has been constantly increasing, not only because new uses have been found for them, but also because their worth has been conclusively demonstrated.

The demand for the electric furnace during the war was so great that furnaces were installed at a more rapid rate than operators could be trained to handle them. It is not at all strange, therefore, that a reaction and oversupply should follow as the result of the great expansion in installations during the war period nor that, because of hastily trained furnace operators, steel below standard should be produced, thereby bringing electric furnace steel into disrepute.

A reaction did occur, and the year 1921 will go down in history as the low-water mark in electric steel progress.

The year 1922 shows a conservative increase in installations—principally for casting work, and a partial list of installations made during the year is given herewith. At the time of writing this article, however, it is too early to include a complete list.

HEROULT

(Complete to December 1)

Name and Address	*Capacity*	*Service*
Elec. Fdry. & Eng. Co., Tacony, Pa...	1—1-ton	Castings
Oil Well Supply Co., Oil City, Pa.....	1—2-ton	Castings
Lorain Steel Co., Johnstown, Pa......	1—3-ton	Castings
Washington Iron Wks., Seattle, Wash..	1—3-ton	Manganese Steel
Tata Iron & Steel Co., India..........	1—3-ton	Melting Fe Mn
Int. Nickel Co., Huntington, W. Va...	1—7-ton	Monel Metal

GREAVES-ETCHELLS

(Complete to December 1)

Name and Address	*Capacity*	*Service*
Ford Motor Co., River Rouge...........	1—60-ton	Hot Metal
Ford Motor Co., River Rouge............	2—10-ton	Castings

MOORE 'LECTROMELT

(Complete to December 1)

There were 20 furnaces of this type installed, but the manufacturer did not furnish a record of installations in response to our request. The following companies, however, have made installations of this type:

Name	*Address*
Brighton Electric Steel Castings Co..........	New Haven, Conn.
Gaddo Steel Products Co..................	Dearborn, Mich.
Berry Iron & Steel Co	Allentown, Pa.
Bucyrus Co.	Detroit, Mich
The Lunkenheimer Co.............	Beaver Falls, Pa.
Sargent & Co......................	Shreveport, La.
Ford Motor Co............................	St. Joseph, Mo.
Lehigh Valley Transit Co................ ...	So. Milwaukee
Studebaker Corporation	Cincinnati, Ohio

The passing year has been interesting from the standpoint that we have witnessed the gradual weeding out of a number of electric furnace concerns. The three principal furnace companies in this country, as enumerated above, installed 28 furnaces in the United States during the first 11 months. On January 1, 1922, the number of electric furnaces already installed in this country was 388, so that there was a total of 416 furnaces either installed or contracted for up to December 1, 1922.

The year 1922 shows a marked tendency toward the use of a greater number of smaller furnaces, particularly among companies operating small steel foundries. The year has not indicated any appreciable interest in electric furnaces among the gray iron or malleable iron foundries, and the writer does not recall a single company installing a furnace for this work. This is quite surprising, for by ordinary means of production considerable phosphorus is necessary for making malleable and gray iron castings, in order to secure proper fluidity; but in the electric furnace any degree of superheat may be obtained and iron much lower in phosphorus content may be used and greater strength and toughness in the castings secured.

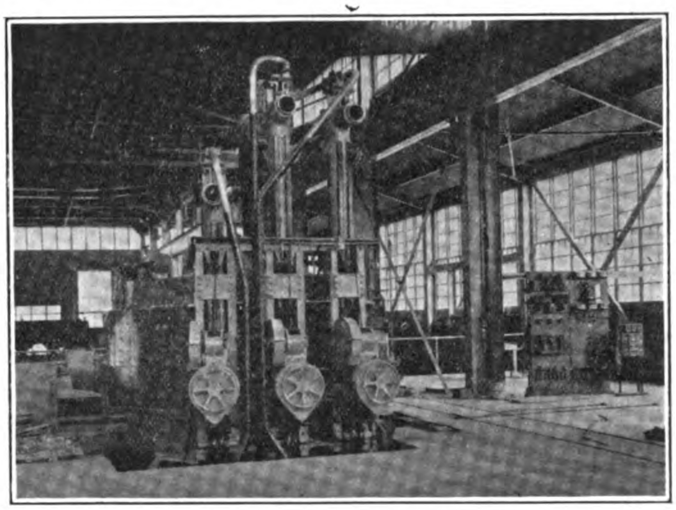

FIG. 1

In the new designs of electric furnaces the structural steel mast is eliminated and the electrode arms and holders are supported from below.

In view of the present high prices of furnace melting stock, the treatment of scrap (formerly considered unavailable or at best very difficult to melt) is of interest and value. A company engaged in making roller bearings has designed and built a machine for briquetting their steel shaving scrap, which we understand produces briquettes of 80 per cent metal. These briquettes are then charged into an electric furnace for melting.

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An operation that has been given extensive consideration in this country has just been started at the works of Edgar Allen & Co., Ltd., Sheffield, Eng., by the Stobie Electric Steel Company. This equipment consists of one 10-ton and one 3½-ton Stobie electric steel melting furnace, the scrap being melted and partly refined by continuous oxidation in the 10-ton primary furnace and approximately one-third of the molten bath transferred at comparatively short intervals to the 3½-ton secondary furnace for finishing. This process is claimed to have advantages from both the electrical and metallurgical standpoint—the load factor being greatly increased by the continuous working of the large furnace and the situation in regard to power factor and current fluctuations also being much improved by treatment of practically molten bath.

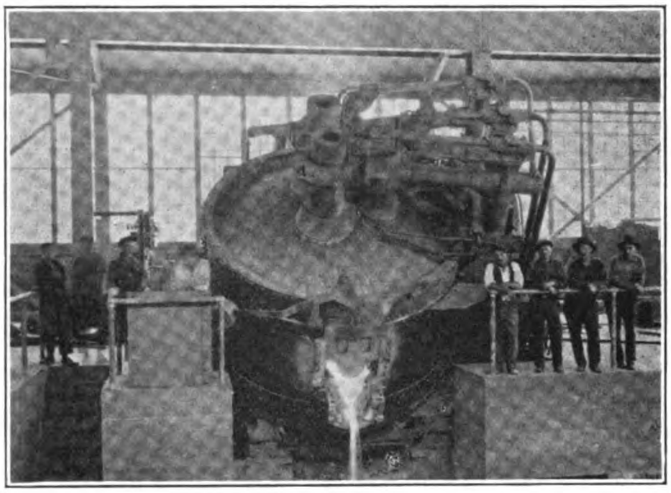

FIG. 2

Second view of new design for electrode holders. The relatively small copper pipe conductor shown can be brought very close together, making it possible to have longer leads and at the same time have them extend beneath the floor.

Other advantages are claimed, such as less space being required for the same output, with several furnaces working independently, reduced crane service, greatly reduced refractory charges and great freedom in choice of melting scrap.

This practice has been tried out in this country at the Halcomb Steel Company with satisfactory results.

Heroult Furnace.

The 7-ton Heroult furnace listed above is of a new design and, while used for the melting and refining of monel metal, is identical in construction when used for steel. The furnace as installed has a basic lining and desulphurization and deoxidation are carried on under a basic slag, as is customary with steel. Instead of using built-up copper busses, the electric current is conducted to the electrodes by means of copper pipes. The pipes also serve to carry water to the electrode holders and the electrode coolers. For electrical reasons a hollow circular section is best for conducting alternating current and as the copper is water-cooled, only about one-third as much copper is required as when using busses. This is particularly true when busses have to be carried over a hot furnace. All designers of electric furnaces have had to contend with the difficulties arising from reactance in furnaces of a large enough size, so that electric current required was considerable; for instance, where the amperes exceeded 7,000. The trouble due to reactance is accentuated by having long conductors pass near or between iron parts.

In most of the familiar types of electric furnaces there is a mast made of structural material, used to support the electrode arms and holders; but by this construction it was necessary to carry the conductors over the top of these masts, in order to avoid proximity to iron parts, with the consequent increase in reactance. This also involved having overhead flexible cables. In the new designs (Figs. 1 and 2) the mast is eliminated and the electrode arms and holders are supported from below.

The cylindrical form of shell was adopted in preference to the dished, or bowl shaped bottom, on account of its structural strength. These furnaces were formerly tipped about a hinge in line with the pouring spout and the furnace was provided with counterweights. In the rocker type of furnace the usual type of rocker rolling on a plain surface requires the cylindrical shell to stand too high above the foundation. In the new design, both the casting on which the furnace rolls and the rocker are curved. By thus dividing the curvatures between the two castings the advantage of the rocker type is obtained without having the center of gravity above the rolling center. The furnace tilts backward—a feature not arranged for in the older design.

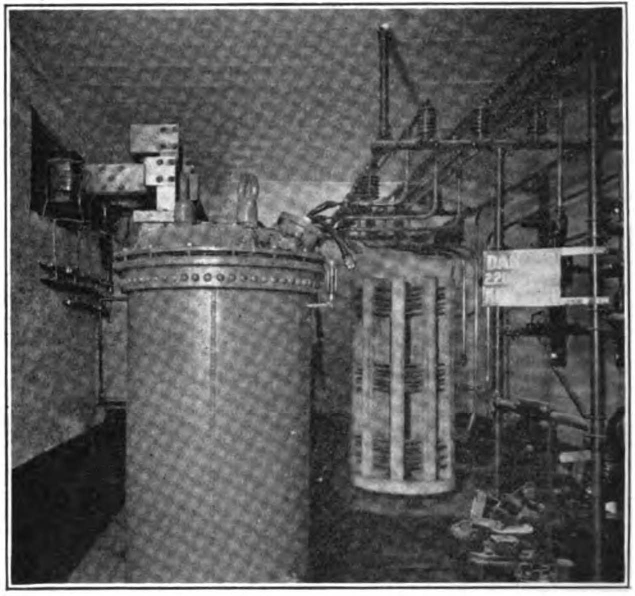

FIG. 3

The transformer, reactor and high tension equipment are located in beneath the floor, making it more convenient to have the electrode supporting mechanism at the back or on the right or left hand side.

The arms carrying the electrodes have been brought in at an angle for the purpose of placing the electrodes as close to each other as possible and to the center of the furnace. This is important in furnaces of high power, to avoid burning the furnace lining, especially where the basic process is used. The electrodes are actuated by winches and motors attached as in the older type of furnace. The tilting mechanism is also similar to past types, consisting of two gear wheels on the same shaft, with connecting rods attached to the furnace. The tilting motor is of 15-hp. capacity.

As will be noted from Fig. 2, the relatively small copper pipe conductors can be brought very close to each other, which makes it possible to have longer leads and at the same time have them extend beneath the floor. The necessary headroom for the passage of cranes is reduced and no flexible cables or other obstructions surround the furnace, the transformer room being beneath the floor (Fig. 3). The arrangement makes it more convenient to have the electrode supporting mechanism attached to the furnace, either at the back, opposite the teeming spout or on the right or left hand side. In the installation illustrated this mechanism is placed on the left hand side.

The transformers are General Electric, single phase, water cooled units of 1800 kva. total capacity. The cooling water passes through the transformers and then through the copper pipe conductors, thence to the electrode holders, thence through a flexible connection and back to the electrode coolers located on top of the roof. The normal operating voltage is 100, although taps are provided to give higher voltages in case the voltage on the high tension line should be below normal. In order to avoid surges on the line and obtain steady operation, it was thought advisable not to have the power factor higher than 90 per cent lagging, and so additional external reactance was provided of the "cast-in" type shown in Fig. 3.

Greaves-Etchell Furnace.

Improvements during the past year on the Greaves-Etchells furnace have been largely of details, this furnace in the smaller capacities having been arranged for four electrodes, similar to larger units, which permits, by a special arrangement of switching and connections, of all the electric power being carried by the upper electrodes or by throwing a switch, transferring a part of it through the bottom or hearth of the furnace. A balanced electrical load, it is said, can be obtained with either system. This allows the top electrodes and full power to be used for melting down when desired and additional use of bottom heat for refining is secured.

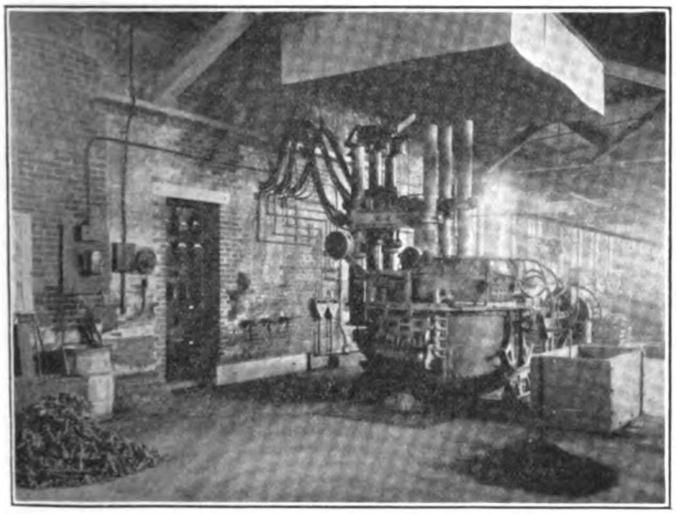

FIG. 4
A typical Moore 'Lectromelt furnace installation.

The largest electric arc furnace thus far installed is being erected at the River Rouge plant of the Ford Motor Company. This furnace of 60 tons capacity has inside shell dimensions 16 ft. by 20 ft. 6 in. of 1-in. plate. The bottom section is flat in the center with 45-deg. bevels on the ends. Two rockers of heavy cast iron section form the main supports and these are assisted by 12-in. I beams placed 27-in. centers. Heavy cast iron brackets carried from the beams supporting the bottom plate to the lower bracing on the side plates support the beveled section of the bottom plate. The rockers are placed so that the two upright channel columns in the rear rest directly on the rocker bearings.

There are two charging doors on each side, one in the rear and a teeming spout in the front, making a total of six doors, all parts of the inside lining being accessible with this arrangement. The charging doors are 33 in. high and 36 in. wide and the teeming spout is 30 in. inside and 27 in. from lip on spout to the center of the arch. All doors are operated by air cylinders having a definite stroke, so that overtravel is impossible. Door sills are 2 ft. 6 in. from charging floor.

The side walls of the furnace are 18 in. thick and the rear wall is given a slight arch, to prevent collapsing when the furnace is tilted. Roof bricks are 12 in. thick on an average, but thicker at ports, so as to give a flat surface for the cooling rings. All doors are lined with 4½-in. firebrick.

A top platform above the furnace, for sustaining the electrodes and mechanism, is supported by six vertical channel columns—two on each side and two in the rear—and two horizontal beams extend from column to column on the sides and two from the rear columns, to a cantilever bracket fastened to the forward side columns. These main supports are suitably tied together and braced by structural members, then covered with a thin plate about ¼ in. thick on which the bedplates carrying the electrode motors and gearing are placed.

There are eight 24-in. diameter carbon electrodes used, which are held in a clamp type electrode holder having two hinges. The outer sections of the holders are cast steel and include an arc of 155 deg. each; the rear section is of bronze, including an arc of 45 deg. This arrangement allows good contact to be made on the rear section which carries most of the current. The rear bronze section is water-cooled and provided with milled pads for connecting flexible bars. The holder is suspended from two points 180 deg. apart by steel chains and guided by means of a rod or pipe secured to the rear section and carried up to and through the sheave support casting above.

The electrode motors are 5 hp., 1150 rpm., d.c., and by means of a double spur gear reduction and a worm gear reduction the speed is reduced to give 32 in. per minute electrode travel. The motors and gearing are arranged so as to be parallel to each other and to the center line of the furnace.

For tilting the furnace the usual screw and trunnion type of heavy design is used. There are two 6-in. diameter screws used and placed on the same centers as the rockers. The gear is operated by a 65-hp. motor with limit switches.

There are four 3,000-kva. Westinghouse transformers used, or a total of 12,000 kva. primary 4600 volts, secondary 90-39 volts with reduced capacity tap. The bus bars which carry the current from the transformers to the furnace are interlaced to a point midway of the electrode travel and flexible bars are carried from there to the holder, except in one instance. To reach the far electrode in the rear group it is necessary to carry a buss across the furnace, terminating in a casting from which the flexible bars are carried to the electrode. This arrangement gives the lowest reactance possible and has the added advantage of permitting the vertical busses to be permanently supported to the upright channel columns.

Moore 'Lectromelt Furnace.

During the year the manufacturer of this furnace has made the largest number of installations, nearly all of which have been in small capacities and supplied to foundries or for casting work. No radical changes have been made in design. This furnace builder is the only one which furnishes a charging equipment with the furnace. The saving of time between heats is very important, as it means a larger daily production and greater efficiency of furnace operation, because the furnace does not cool off appreciably between heats. With the mechanical charger, the time of charging a 3-ton furnace has been reduced, it is said, to as low as three minutes. Fig. 4 is a typical furnace installation and Fig. 5 shows the condition of a roof after 672 heats.

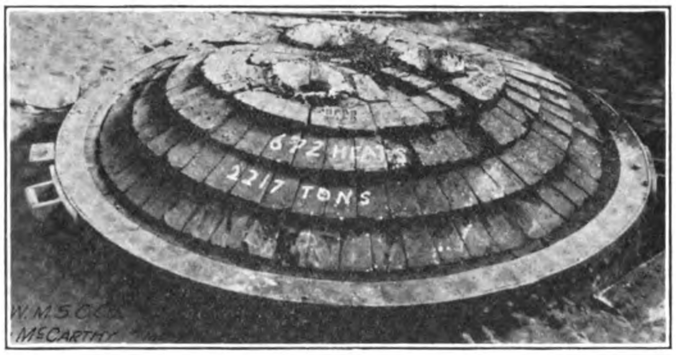

FIG. 5

Showing the condition of a roof after 672 heats.

ELECTRODES

Density.

The need for an improved electrode has been met by at least one of the electrode manufacturers. As is well known, the density of an electrode is its mass per unit volume, and it is customary to measure density in the C G S system, as the density of water in this system is equal to unity. Density and specific gravity, therefore, have the same significance. The density of the electrode, as commonly expressed, is the weight in grams of a cubic centimeter of the electrode. As all forms of carbon, with the exception of the diamond, are more or less porous, it becomes necessary, in thinking about density, to consider this condition of the material. When speaking of the density of the solid portion of the electrode alone, the term "real density" is used, and this ordinarily means the weight in grams of a cubic centimeter of the real solid material of which the electrode is composed. If the density of the electrode as a whole is considered, however, the term "apparent density" is used, and this means the weight in grams of a cubic centimeter of the electrode taken as a whole; that is, including both the solid matter and the pores in the relative proportions in which they exist.

Of these two kinds of density, the apparent density is of the most interest to the electrode user, as he can determine it easily by weighing and measuring the electrodes. If the weight is in grams and the measurements in centimeters, the apparent density, as ordinarily given, is found directly by dividing the weight by the length, times the cross-section calculated from either the diameter or the circumference. If the weight is in pounds and the measurements in inches, an equally good value for apparent density is found by the same method. If the value is obtained in pounds per cubic inch, it may be converted into the ordinary unit "grams per cubic centimeter" by dividing by 28.7. The ratio of the difference in real and apparent density is the porosity.

The National Carbon Company, during the past year, has brought out an electrode of considerably higher density, and the early reports which the manufacturer has secured from users indicate a much better performance and less breakage. Reliable data upon electrode consumption and breakage can only be secured over an extended period and users are not yet in a position to give this information.

Electrical Resistivity.

Electrode manufacturers do not seem to lay much stress upon electrical resistivity of electrodes, but the writer is strongly of the opinion that low resistivity is highly desirable, even if only a means of preventing power waste and thus assist in keeping the temperature of the electrode as low as possible. The resistivity of an electrode is the opposition which a unit volume of it offers to the transmission of a unit of power; that is, a unit of energy in a unit of time. In considering electrical resistivity it is customary to use the unit "ohms per inch cube." If such a unit is chosen, the electrical resistivity of an electrode is equal to the voltage required between opposite faces of an inch cube of an electrode, to cause a current of one ampere to flow through the cube.

Thermal Resistivity.

The terminology used in considering thermal resistivity has not become as well standardized as in the case of electrical resistivity. Probably the most convenient unit of thermal resistivity is the thermal ohm. When using this unit the thermal resistivity of an electrode is equal to the difference in temperature (in degrees centigrade between opposite faces of a one centimeter cube) required to cause a flow of heat through the cube from one face to the opposite face, equal to one watt. Conductivity is the reciprocal of resistivity and is found by dividing 1 by the resistivity.

It is hoped that electrode users will check up electrodes carefully and preserve a record of their performance for study, as it is only by a very careful analysis of operating results that plans can be laid for improving the product.

Electric Furnace Tests.

During the year very extensive tests were made by the writer upon 6-ton Heroult furnaces, involving the use of an oscillograph and multi-exposure, high speed camera. Some very excellent photographs of the electric furnace arcs were secured simultaneously with the recording of power input, wave form, etc., and it is believed to be the first time this has been done. The complete results of the tests will be published during the early part of 1923 by the Association of Iron & Steel Electrical Engineers.

Non-Ferrous Field.

In the non-ferrous field there has been a comparatively small number of furnaces installed. As yet, there does not appear to be an ideal type of brass furnace developed to meet all conditions. For instance, one type of furnace is suitable for continuous operation such as in our large brass works and where the zinc content is high, but for general foundry work in the making of brass, another type seems to be more suitable. If a furnace could be developed which was economical and would melt rapidly with low volitilization loss, which could be sold over the counter very much as a motor and which would not involve excessive engineering or service, it would be an ideal furnace. There are some 3,500 indus-

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tries in this country and to date only about 2 per cent employ electric furnaces. There is a big field yet to be developed, but the real field is among companies having brass foundries and not among the large brass mills.

One of the important developments of 1922 was the bringing out on August 1 by the General Electric Company of a novel type of induction furnace for melting non-ferrous metals and alloys (Fig. 6). Several of these furnaces have since been put into operation and are more than meeting expectations, the cost of melting being reduced to a very low figure. For example, in one plant the output of one furnace melting 60/40 brass is now approaching the 500,000-lb. mark and the energy consumption is something under 180 kw-hr. per ton. This, of course, means continuous operation in connection with a large rolling mill, and on such a basis the cost per ton figures out as tabulated below.

Cost of melting 60/40 brass at the rate of 45 tons per 6-day week and on the basis of an uncompleted run of 250 tons:

Power, 180 kw.-hr. at 2c	$3.60
Lining (labor and material $200)	.80
Melting labor, 50c per hour	1.47
Ladles and preheating	1.00
Depreciation, interest, etc.	.33
Total	$7.20

This figure does not include plant overhead nor superintendence, but on the basis of adding 10 per cent for unforeseen contingencies we have a total melting cost of $7.92, or somewhat less than .4 of a cent per lb., which, we will agree, is a very low figure, especially when we consider the metal is melted under the best conditions and gives a product of the highest quality. The labor item is on the basis of one man per furnace, but it should be possible for one good man to handle at least two furnaces and possibly more.

Another field for this furnace which holds considerable promise is in the melting and superheating of iron for high grade castings which, it is expected, will supplant the arc furnace which is so much superior to other types of furnace in the melting of that particular form of scrap called "cast iron borings." This material, which is almost impossible to handle in the ordinary cupola and is also troublesome in the electric arc furnace, melts rapidly and without trouble in the induction furnace, especially where there is constant and uniform circulation of the metal. The radiation losses are very small in this furnace, so that the standby losses formerly considered so objectionable are now so small as to be practically negligible. With so new an equipment it is almost impossible to visualize all possibilities, but from the operating data already obtained we believe this type of furnace will be an important factor in the melting of practically all ferrous and non-ferrous metals and alloys which are handled in quarter-ton lots and larger.

When operating conditions are normal electric furnace melting of brass or copper can be conducted at close to one-half the cost of crucible melting; such, however, are obtained only on a fairly full operation. The use of electric furnaces in American mints where silver and gold coins are made, has shown a considerable increase While aluminum and its alloys are more difficult to handle than some of the others, their manipulation in electric furnaces was reported in most cases as satisfactory and economical. Where large scale operation is possible it is evident that electricity has come to stay, not only in brass and copper, where it had its first success, but in practically all non-ferrous alloys.

Resistance Type Furnaces.

This article while dealing principally with arc furnaces, would not be complete without mention of one of the most encouraging and profitable fields, both for the manufacturer and the central station—that of the resistance type furnace for vitreous enameling, baking, drying, japanning, heating, tempering, annealing, etc. A furnace of this type represents a steady uniform load of high power factor and it is usually an off-peak load.

Electrical manufacturers are looking for some very encouraging business along this line and the central stations feels that the heating load within the next five years will equal the present lighting load. There are many special applications for the resistance furnace, but most of these are not entirely commercial.

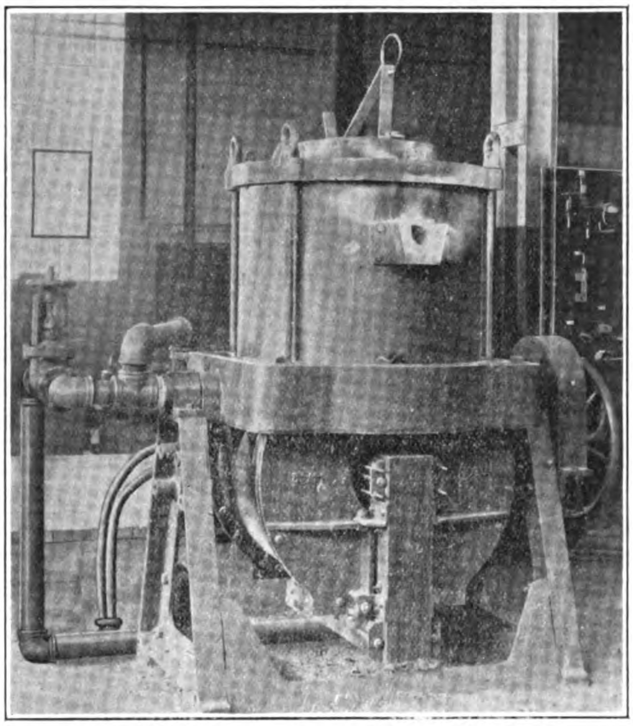

FIG. 6

A 75-kw. repulsion induction furnace brought out by the General Electric Company for melting non-ferrous metals and alloys. It is said to be very successful and melting costs are low.

With the fertilizer market still suffering from the effects of the war, there does not appear to be any activity in furnaces for nitrogen fixation. If the Muscle Shoals Plant No. 2 is ever operated as a fertilizer plant, this, of course, will utilize cynaide processes, so that we shall probably see a little activity along the line of the arc furnace.

A very novel type of resistance furnace known as the "counterflow car type," was installed during the year by the Electric Furnace Construction Company, manufacturers of the Greaves-Etchells furnace. This counterflow furnace utilizes the principle of recuperation of heat given off from the cooling of the outgoing charge to the incoming charge. In such a furnace thermal efficiency is greatly increased, for since a large proportion of the heat units given off by the cooling charge is absorbed by the oppositely moving entering charge, a lesser expenditure of heat energy is necessary to bring the latter to its final temperature after being preheated by radiation from the outgoing charge. If the funace were made long enough the annealed work could give up

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all its heat to the incoming charge, and thus the only energy to be expended would be that necessary to compensate for radiation from the furnace walls. The investment on a furnace large enough to accomplish this result would be greater than the savings effected. Obviously, there is a point at which the greatest efficiency of recuperation for the least burdensome investment will balance, and it is for this point that the designers of the furnace under discussion aimed.

This type of furnace is well adapted for tonnage work, the one mentioned having a capacity of 20 tons per 24 hours at 1450 deg. F. For a mill having a variety of materials which must be annealed at different temperatures, this type of furnace is not adapted, but with continuous operation at a definite prolonged temperature it will not only turn out a steady production, but at a cost comparing favorably with other kinds of fuel.

The electric furnace is a recognized factor, not only in the manufacture of tool and alloy steels and non-ferrous alloys, but also for special alloys such as "Nicrome," "Rezistal," "Stellite" and stainless steels, besides an endless variety of the simpler alloy and carbon steels from the mildest to the hardest tempers.

As recently mentioned by Dr. Mathews, "it is the astonishing flexibility of the electric furnace—versatility, we might call it, that has attracted the attention of the meallurgical world in almost every branch of smelting, melting, refining, heating and even baking metals. To those of us who have watched its growth from the start, it seemed very slow in achieving the recognition we felt must inevitably come to it, but at last our early confidence has been confirmed in every steel making country, because its products have filled almost every expectation in every field wherein it has been thoroughly tried.

"The present success is due not only to the original inventors of the basic processes, but also to the active co-operation of the great manufacturers of electrical equipment, furnace designers and builders, makers of refractories and electrodes and a group of earnest metallurgists.

"When users acquire a full appreciation of what clean, sound steel means in terms of national efficiency, safety and economy, we shall see more rapid growth than has as yet been seen. Its usefulness to engineering and industry has just begun."

LIFTING MAGNETS*

During the war there arose proposals that ships be equipped with huge magnets which, when energized, would draw submarines to them where, being helpless, they could be destroyed. In peace times equally impossible proposals are made with respect to magnets. Such propositions overlook the fact that while magnetism may be detected through long distances by means of delicate instruments as, for instance, the earth's magnetism by the compass, yet drawing power in large, usable, effective quantity can only be exerted through short distances up to 12 or at the most 15 inches.

Where the magnet can come near or in contact with its pull or its load it is wonderfully effective as its universal use in steel mills, blast furnaces, foundries, forge plants, scrap yards, railroad yards and all other places where iron or steel in quantities must be handled proves, and in all such situations a magnet will save its own cost in three to 10 months' time.

Most magnets are used for loading or unloading iron or steel materials but there are many related uses not so common or well known but equally interesting and important economically. One of these latter cases is quoted below.

Fig. 1 shows two rectangular super-magnets mounted on a beam and controlled in parallel by the operator in the crane cab. These magnets are two of nine used by the rail mill of The Inland Steel Company at Indiana Harbor, Ind., to handle and load its product. The load shown consists of thirteen 90 lbs. per yard rails, each 40 feet long, total weight of rails 15,600 lbs. These magnets require little head room, are strong mechanically and all their magnetism is down on the job of lifting. They will lift 17 or 18 such rails if stacked in double locked layers.

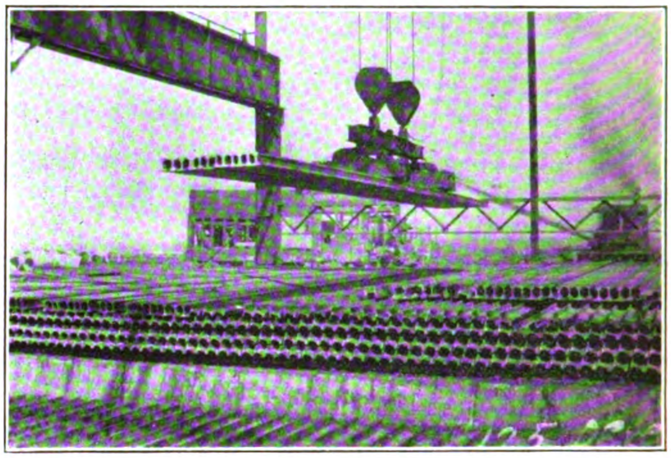

FIG. 1

Two rectangular super-magnets mounted on a beam and controlled in parallel by the operator are used by the Inland Steel Company to handle and load its product.

Two 20-in. round magnets on a beam and controlled in parallel by the operator in the crane cab are used in the Kelly-Jones, Chicago warehouse to store and afterward to reload, on delivery wagons, pipe from the smallest to the largest sizes. The system is effective and saves time and space.

A magnet about 40 inches in diameter and having an energizing coil wound for continuous service is supported above a belt conveyor carrying silver ore at the Fresnillo, Mexico, plant of the Mexican Corporation, S. A. The object of this installation is to extract stray or tramp iron or steel from the ore as it passes under the magnets. If such pieces are not taken out they will break the crushing rolls causing great delay and expense. Small magnets have been in use for this purpose in flour mills for many years but in late years many large ones, such as that shown, have been used over belt conveyor of copper and lead ores, also coal and other materials to save the crushing of machinery and in some cases also to prevent the admixture of iron with the product.

There are many other useful and interesting special magnet applications but always the limitations noted in the first paragraph must be remembered.

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*The data for this article was furnished by the Ohio Electric & Controller Company of Cleveland, who make the magnets illustrated.

Electric Power Application in the Steel Mills

Motor-Driven Rolling Mills Have Proven More Economical Than Steam Driven During Recent Depression—Turbo-Generators of 10,000 kw. Find General Acceptance in the Larger Plants.

By G. E. STOLTZ*

THE fact that the last year has been a lean one has turned the minds of operating engineers from the problem of producing a large tonnage to one of economy of operation and the production of higher grade material.

A comparison of steam driven and electric driven plants producing practically the same material very clearly indicates the economy of electric drive. A plant where the predominating method of drive is electric, usually consists of a single power station either gas engine or steam turbine driven, utilizing such waste gases from the blast furnaces as are available, and the remainder from coal fired boilers.

This generating plant carries a fairly constant load and the power plant as a whole operates as a very economical unit. The energy is distributed over the plant by means of electric cable which naturally eliminates losses that are obtained in other systems of energy distribution.

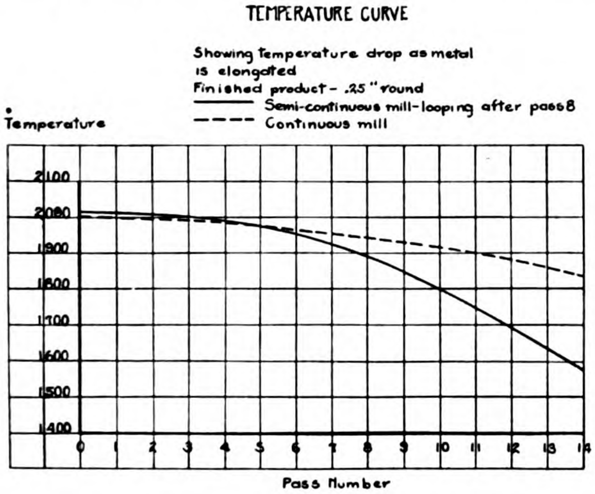

FIG. 1

Shows two temperature curves super-imposed. The two curves indicate the comparative temperature drops between the two rolling methods described.

During the past year the increased generating capacity has been provided by the installation of several 3,000-kw. gas engine driven generators, but by far the greatest increase has been provided by the installation of steam turbines. The predominating size of turbine installed during the last year is 10,000-kw. capacity. Apparently the operating engineers feel that electrification is to be made on rather a large scale, and they are not justified in considering turbines of smaller capacity.

The Tennessee Coal, Iron & Railroad Company is utilizing purchased power to supplement the power which they generate in their own plant. In this instance, the power generated by the steel plant is 25 cycles, while the purchased power is 60 cycles. Some of the recent installations made at this plant have been designed for 60-cycle operation so that part of their equipment operates directly on the power company's line, while the older equipment operates on their 25-cycle plant. During the last year a 7150-kva. frequency changer has been installed to tie these two systems together. By this means it will be possible to transfer power from one system to another as required.

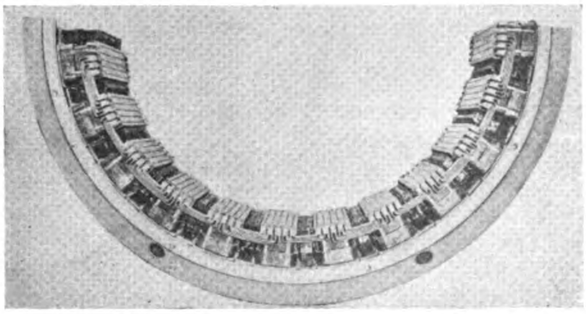

FIG. 2

Shows the top half of a reversing motor frame with special pole face compensating winding.

There is no doubt but what the tendency to operate a local power plant in parallel with central station power is increasing. This decreases the amount of spare capacity needed, and although it is essential to utilize waste gases in the steel plant there is no question but what purchased power can be used to advantage in many cases. In past years there has been considerable objection to purchased power, due to interruptions. In many localities power companies are appreciating to a greater extent the necessity of continuous operation and are providing service to which little objection can be made.

The depression through which we are passing has naturally reduced the number of new mills installed, so that a large proportion of the rolling mill motors installed in the past year have been to replace steam engines on existing mills. New mills that have been installed in general are of the finishing type and there is a tendency towards the use of adjustable speed apparatus operating stands in tandem. This reduces the length of the loop between stands and permits finishing the steel at higher temperature, or it permits finishing smaller sections at the same temperature. Fig. 1 is a temperature curve taken on two mills rolling small rounds. It will be noted that on the continuous mill the temperature is 250 deg.

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*General Engineer, Westinghouse Electric & Manufacturing Company, Pittsburgh. Chairman, Power Committee, Association of Iron & Steel Electrical Engineers.

higher as the metal passes through the last stand, than on a semi-continuous mill where the metal is exposed as it is looped from one pass to another. The difference in power consumption, of course, is very great and the ability to finish a uniform cross section is naturally reduced as the steel is rolled at lower temperature. In the last year we have, therefore, seen a number of mills designed with d.c. compensated motors driving the individual stands. This makes it possible to locate these stands in a continuous train, and the loop between the individual stands is governed by adjusting the speed of the individual motors. It is essential that the speed of these motors be practically constant at all loads, and to do this compensated motors have been used.

The speed of d.c. motors can be adjusted by means of the field current in the shunt winding, but as the load changes the reaction from the armature current tends to distort the field flux having the same effect as a slight change in the field current of the shunt windings. To counteract this magnetizing effect of the armature current, a winding is placed in the pole face of the shunt fields. This winding is connected in series with the armature and is arranged so that its flux counteracts that of the armature winding. In this manner it is possible to adjust the speed of the ordinary d.c. motor to any predetermined value desired, and have the motor maintain this speed within its range of capacity. Fig. 2 is a view of the stationary part of the compensated d.c. machine and shows the compensating winding in place in the pole faces.

The use of electric locomotives for switching service in the railway yards of our large steel plants has been attracting considerable attention. Due to the fact that the d.c. auxiliaries in a steel plant are supplied with power from a 250-volt system, this voltage offers itself as the logical power to use on electric locomotives. If the yards were extended over long distances this would naturally result in the problem of transmitting large currents at low voltage, but railway yards in a steel plant are usually congested and confined to a small area. In addition to this it is customary to provide d.c. substations at a number of points scattered over the plant so that electric locomotive would always be fairly close to a substation. For this reason the distance which d.c. need be carried is usually very small. The speed of the locomotive required is not high so that the actual amount of power required is small. Although the momentary demand for power by an electric locomotive may be comparatively high, still the service is very intermittent and in several instances where plans were drawn up to electrify yards, it has been found that the amount of substation equipment that need be added to transform power from a.c. to d.c. is almost negligible. The demands from electric locomotives would sandwich in with the present load, so that this additional load would hardly be noticed.

The Edgar Thomson Works of the Carnegie Steel Company have had a 30-ton trolley locomotive in service for a number of years in their open hearth department and has given excellent service. The loads handled in this department are not heavy, but there is no reason why this type of locomotive equipped with shoes for third rail could not be extended out in the yards. At the present time the Sparrows Point plant of the Bethlehem Steel Company is placing in service a 20-ton electric locomotive to operate on a third rail, 250-volt d.c. grounded system. It may be found necessary to supplement this type of locomotive with certain locomotives equipped with reels or storage battery, which could operate in places where it is undesirable to install a trolley or third rail.

Industrial heating is another new subject which is receiving attention of the steel mill industry. The use of electricity in soaking pits has been discussed a number of times, but as yet no one has offered a practical solution to this problem; we believe mainly for the reason that most of the work done in industrial heating in the past has been confined to temperatures below 2,000 deg. F. It is only natural in a new field of this character that the first work should be done at low temperatures, such as is required in tempering and annealing ovens.

EFFECT OF MANGANESE ON STEEL

A method of preparing very pure iron has been developed at the Bureau of Standards and with this iron as a base various commercial steels and other iron alloys have been made for the purpose of testing them without the complicating effect of impurities which are usually present in commercial iron and steel.

These facts are set forth in Scientific Paper No. 464 of the Bureau of Standards, which is the third of a series, and deals with the effect of manganese on the structure and properties of the steel.

The use of managanese as a strengthening agent in addition to the carbon is the subject with which the investigation was chiefly concerned. Manganese is also used as a deoxidizer and as a desulphurizer, but these uses are better understood.

The use of higher percentages of manganese for producing high tensile properties in low and medium carbon steels has been recommended at times by various metallurgists and to some extent such recommendations have been carried out in commercial practice. The results obtained in this investigation of the structural effects of manganese in steel strongly confirm such recommendations concerning this use of the element.

The general effect of manganese may be concisely described as a "restraining influence" so that the pearlite or carbon-bearing constituent of steel, even after annealing, exists in a very fine grained condition if considerable manganese is present. In this respect the steel resembles in structure the condition which usually obtains in similar steels of low manganese content after rather rapid cooling, for example, air-cooling. The mechanical properties of the annealed high manganese steel are quite similar to those obtained in the lower manganese steel by cooling it more quickly.

Ordinary carbon steel containing approximately 0.90 per cent carbon is termed by metallurgists, "eutectoid" steel, since it presents a uniform structure of pearlite. For many purposes such a steel is the best one to use. An additional effect of manganese upon steel is to shift the eutectoid composition to lower carbon contents by approximately 0.12 per cent for each per cent of manganese.

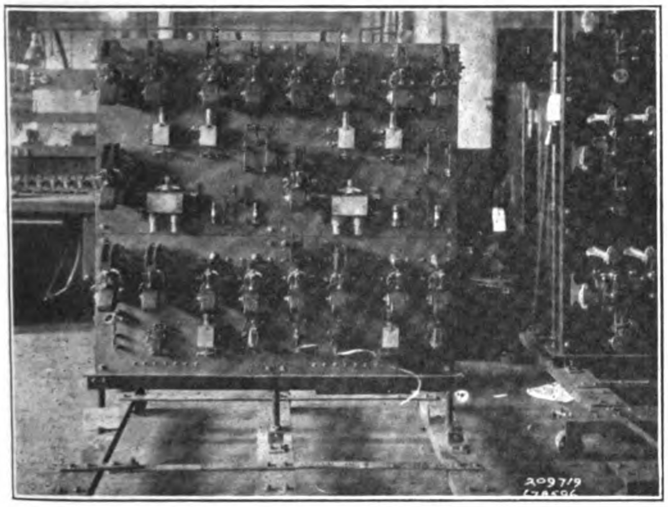
Manganese also appears to have a very noticeable effect upon the rate at which high carbon steels, such as carbon tool steels and file steels, assume the granular or "spheroidized" state—a condition which for many purposes is very desirable. Manganese exerts its characteristic retarding influence upon this change. This paper, "Preparation and Properties of Pure Iron Alloys: III. The Effect of Manganese on the Structure of Alloys of the Iron Carbon System," Scientific Paper No. 464 of the Bureau of Standards may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 10c a copy.

Material Handling for Steel Mills

Developments in Steel Mills Now Accepted Standards of Comparison—Various Types of Bridges and Drives Employed—Controls.

By R. W. McNEIL*

IN these days when the subject of mechanical handling of materials is kept constantly before the public by advocates of improved transportation and terminal facilities, accomplishments in the steel industry stand forth as an example of what may be accomplished in other fields. The art of handling bulk materials has reached such a high state of perfection in the steel industry as to cause practically all writers on material handling subjects to refer to the accomplishments in this field when arguing for better methods in other fields. This enviable position has not been attained by accident, but is rather the result of keen competition which made it imperative that all material handling costs be reduced to a minimum. Early in the steel industry as we know it at the present time, the immense amounts of iron ore, coal, limestone and coke which had to be handled and stored led to the development of a large class of special machinery. In this development, electricity played an important part, until at the present time, it is the universally accepted power for the ore unloaders, car dumpers, ore and coal bridges, larry cars and skip hoists used in and around steel mills.



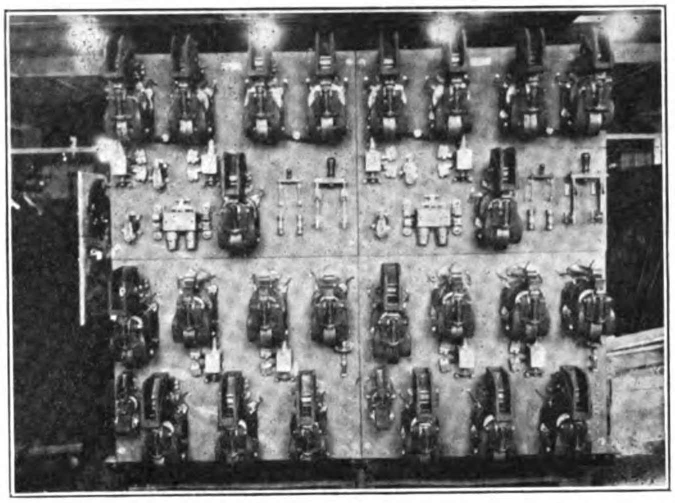
Full magnetic bridge control.

Cranes and Bridges.

The huge gantry cranes, variously known as ore or coal bridges, according to the material which they are designed to handle, form one of the most conspicuous features of the landscape about a steel plant. They are generally very, very large affairs, from 400 to 600 ft. in length, and from 75 to 100 ft. in height, while their weight may go considerably over 1,000 tons.

The two different types of bridge, as distinguished by the method of operation, are in common use. These different types are known as the man-trolley type, and the rope-trolley type.

In the "man-trolley" bridge, all hoisting and propelling motors and machinery together with a cab containing the control equipment and the operator, are mounted on a carriage which runs the length of the bridge. This arrangement gives the operator an unobstructed view of the bucket at all times.



Trolley travel control—provides for operation of motors in parallel.

In the rope operated bridge, the motors and other machinery are located in a stationary motor house on one leg of the bridge, and power is transmitted to the carriage for hoisting the bucket and moving the carriage by means of steel ropes or cables. In this case, the operator is located to obtain the most comprehensive view possible from a single position on the bridge.

Drives.

Various methods of drive may be used with either of the above classes of bridges. The most common method on bridges of the man-trolley, which is used principally for the large bridges, is to employ two motors for the hoist, one geared to the holding drum, and one to the closing drum. The trolley or rack may be driven by one or two motors; sometimes these will be geared to the truck wheels of the carriage, or to a cable drum, while at times both methods are used. The chief functions of the equipment are the closing, hoisting, conveying and dumping of an automatic grab bucket. Auxiliary drives for moving the bridge are always used and auxiliary drives for operation of hopper gates and aprons are sometimes used.

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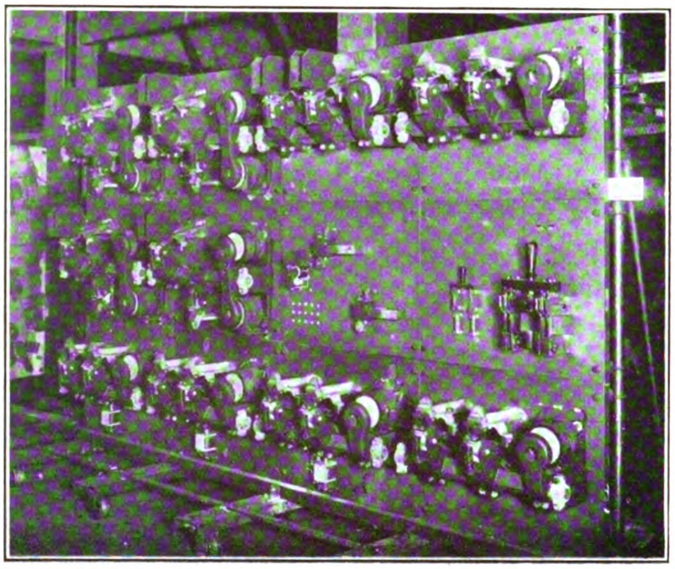
The proper selection of electrical equipment for a large ore or coal bridge is quite an important problem. Direct current, series wound motors have been most widely used for driving the various mechanisms of the bridge, on account of the superior control features which are easily obtained with this type of motor. Alternating curent, phase wound induction motors can be used, however, if economic considerations make it desirable, and quite a number of successful bridges have been so equipped.



Hoist control—provides for independent operation of the two-hoist motors.

As an example of the electrical equipment involved on one of these large bridges, a coal handling bridge recently installed at a steel plant in the Pittsburgh district is cited. This bridge has a total length of 600 ft., 400 ft. between supports, and was designed to handle coal from river barges to a stock pile, and from the stock pile to railroad cars. It is equipped with two man-type trolleys, each on its own runway, and each equipped with a 6-ton coal bucket. This bridge was designed to handle 600 tons of coal per hour with an average trolley travel of 285 ft., and an average hoist of 75 ft. The hoisting speed with loaded bucket is 500 ft. per minute, while the free running speed of this trolley was designed for 1,000 ft. per minute.

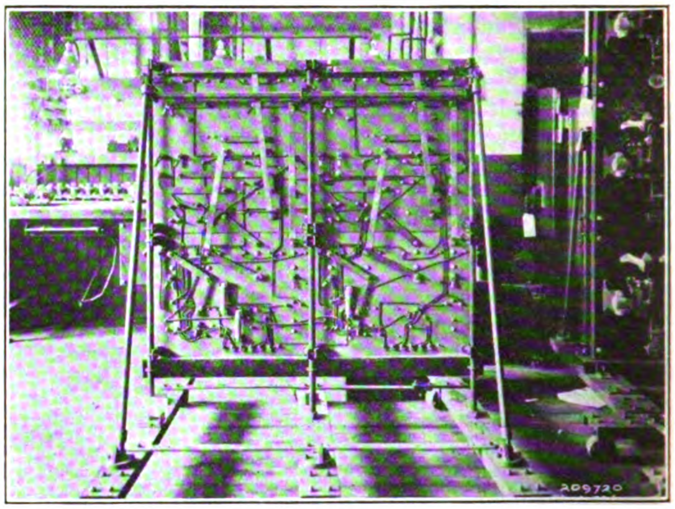
Power is supplied to the bridge at 230 volts D. C., and 18 motors having a total rating of 1,416 hp. are used for driving the different motions. The hoist motors, of which there are two for each trolley, are of the entirely enclosed, separately ventilated, series wound type, and are rated at 175 hp. each continuously. In order to insure cool operation of these motors, each motor is connected to a small individual motor driven blower. This blower forces air into the motor housing through an opening under the commutator, and out at a similar opening on the coupling end, the motors being made with internal baffles to insure efficient cooling of all parts. The trolley motors, of which there are two to each trolley, are rated at 100 hp. each. They are similar in construction to the hoist motors, and use the same scheme of separate ventilation.

For the bridge drive, eight 37 hp. intermittent rated motors are used, four motors being used to drive each end of the bridge. These motors are of the series type, and are totally enclosed. In order to anchor this bridge against severe wind storms, each leg of the bridge is provided with a rail clamp. Each of these clamping devices is provided with release mechanism driven b ya 10 hp. series wound motor.

Controls.

All of the control equipment on this bridge is of the full magnetic type, and all motors are equipped with shunt wound magnet brakes. Each operator's cab contains five master controllers—two for the hoist, one for the trolley, and two for the bridge travel. The magnetic contactor panels and resistors for the hoist and trolley motors are located on the trolley carriage, while those for the bridge travel are located in the legs of the bridge adjacent to the bridge motors.

The hoist control in each trolley provides for independent operation of the two hoist motors; six control points are provided in each direction on the hoist controllers. The control is arranged to give automatic acceleration under the control of current limit relays in hoisting, and to give dynamic braking in lowering. A limit switch is used to prevent over-travel in hoisting.



Rear view of bridge travel control which provides for independent operation of each end of bridge.

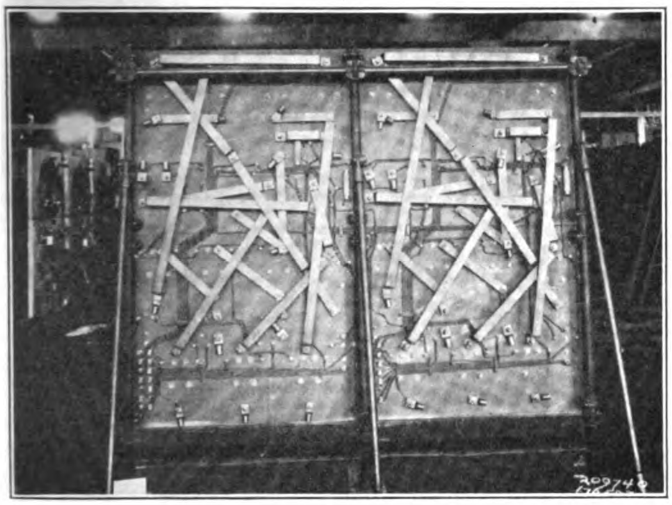
The trolley control provides for operation of the two trolley motors on each trolley in parallel, although separate resistors, reversing and accelerating contactors are used. The control provides for three power points, one drift point, and two dynamic braking points, in each direction. Slow down and stopping of trolley are provided for by track limit switches at either end of travel.

The bridge travel control provides for operation of each end of the bridge independent of the other end. The four motors driving one end of the bridge are operated in parallel from one master controller, each motor, however, being provided with its own contactor panel and resistor, so that one motor may be isolated from the others. Master controllers are provided in each of the operator's cabs for control of the bridge travel. In order to prevent interference, the control circuits are interlocked to render either master inoperative unless the other is in the off position, this interlocking being arranged, however, so that the second man cannot stop any operation which the first man may be proceeding with. Skew limit switches are used to prevent one end of the bridge getting ahead of the other.

other, except by a predetermined amount. The bridge travel control provides three points in each direction, the first point being a shunted armature point for creeping speeds, and for slow down. The bridge travel control is interlocked with the rail clamp control in such a manner that operation of bridge travel master controller releases rail clamps before energizing bridge motors, similarly de-energizing bridge motors applies rail clamp.

While the bridge for which the above equipment was designed possesses some unusual features, such as the double trolley and the dual control of the bridge propelling mechanism, the equipment used is fairly typical of ore and coal bridges.

Although the ore or coal bridge is the principal material handling device found around steel mills, it is frequently supplemented by unloaders and car dumpers. Unloaders are used principally for the unloading of boats and barges. They are frequently of the same general construction as the large bridges, except that they are of relatively short span and have no provision for storage space. Another type which is used extensively is the Hulett or stiff legged unloader. These unloaders take the material from the boats or barges and either load th esame into railroda cars, or into a trough where it is picked up by the large bridge. Where the material arrives at the steel plant by rail, car dumpers are frequently used. These dumpers consist of a cradle on to which the loaded open top car is run and clamped in place, after which the car and cradle are overturned, emptying the contents from the car. In steel mills, these dumpers are usually of the moving type, and dump into a trough alongside the runway of the ore bridge.



Rear view trolley travel control.

THE ELECTRIFICATION OF INDUSTRY

By J. M. CURTIN*

The present generation has seen the beginning of the commercial use of the electric motor and in this relatively short time, so much progress has been made by the engineers of many nations in the perfection of apparatus for the generation, transmission and utilization of electricity that from a very crude beginning the electric motor is rapidly becoming the accepted form of power in all industries and in all countries.

Although the growth of the electrification of industry has been rapid and continuous in the past, there is every reason to believe that the future will bring even greater opportunities for those connected with the many phases of the electrical industry and for those in other industries who will take advantages of the developments in the electrical art.

Where water, steam and gas power once held full sway in the industries of the United States, there is now being furnished by the electric motor approximately 65 per cent of the power used. This is indeed a great growth when it is taken into consideration that it has almost all been accomplished since the beginning of the present century and, at the present rate of increase, within the next five years approximately seventy-five per cent of the power used by the industries of this country will be furnished by the electric motor.

In the making of iron and steel, more power is required than in any other single industry.

In 1904 there was installed in this industry 2,900,000 hp. of which 550,000 hp. or 18.4 per cent, was electric motors.

In 1914 the total horsepower installed was 4,060,000, of which 1,490,000 hp. or 3.7 per cent was electric motors.

In 1919 the total horsepower installed was 5,630,000 of which 2,811,000 hp. or 50 per cent, was electric motors.

This industry is typical and shows the extent to which the manufacturers of this country are adopting this modern form of power and the great part it is playing in converting the natural resources of a country into finished products for the use of mankind.

The research and designing engineers are rapidly accomplishing the successful application of electrical machinery to those processes as yet unelectrified, the great advances made in the apparatus for controlling the actions of the motor, now making possible many applications heretofore accomplished by other means—a notable example being the sectional motor drive for paper machines by which great economies are effected in the making of paper.

The use of electric heating apparatus in industrial process is one of the big problems of the future, and it may be conservatively estimated that the progress within the next 20 years in developing apparatus for this purpose will be as great as the accomplishments in illumination and power in the past.

ELECTRIC FURNACE REFRACTORIES

In a general study of electric furnace refractories, being made by the Ceramic Experiment Station of the United States Bureau of Mines, Columbus, Ohio, conductivity tests are to be made of alundum, carborundum, sillimanite, spinel, silica, and magnesite.

POWDERED COAL FOR GENERATION OF STEAM

In co-operation with the Combustion Engineering Corporation, tests are to be conducted by the Bureau of Mines at the River Rouge plant of the Ford Motor Company on the largest boilers so far constructed. These tests will supplement the knowledge gained in previous tests on differently designed boilers when heated by powdered coal.

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*Manager Industrial Department, Westinghouse Electric & Manufacturing Company.

New Motor-Driven Rolling Mill in the Chicago District

Current Purchased from Super-Power System—Producer Gas Used in Heating Furnaces.

By H. E. DAVIS*

An addition to the bar mill capacity of the Chicago district was recently put in operation by the Inter-State Iron & Steel Company at its South Chicago plant.

The new equipment consists of a Morgan continuous merchant bar mill driven by a 1,500-hp. a. c. motor.

Description.

The mill was installed to roll special alloy steels. It produces rounds from 5/8 in. to 3 in. in diameter with equivalent sections of squares, and flats from 1½ in. to 6 in. wide, with a minimum thickness of 3/16 in. The furnaces and mill were designed and built by the Morgan Construction Company. The balance of the equipment was furnished by other companies, as indicated. The mill is housed in a building 105 ft. by 900 ft., with a Pond type roof. There are two Morgan Construction Company gravity charge continuous furnaces with hearths 13 ft. by 34 ft. Gas for furnaces is supplied by three Morgan 10 ft. gas producers

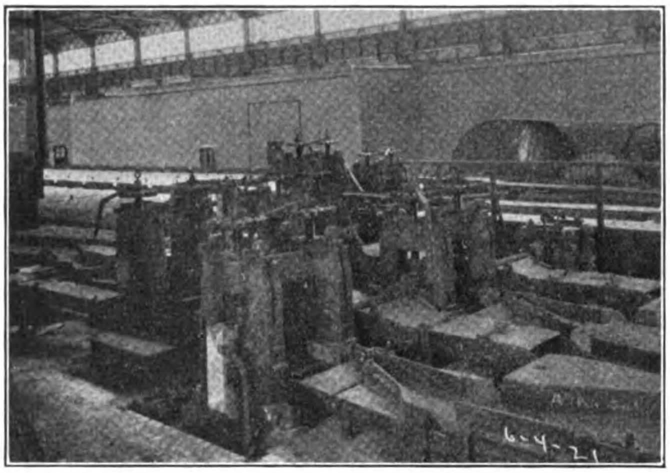

FIG. 1—STAGGARD-DUO TYPE CONTINUOUS MILL

The mill consists of a six-stand continuous rougher (Fig. 1) and a six-stand finishing mill of the staggard-duo type. The roughing mill has two stands of 18-in. rolls and four stands of 16-in. rolls, and is driven by a single speed wound rotor induction motor direct coupled to the jack shaft. The finishing mill has two stands with 14-in. rolls and four stands with 12-in. rolls. The mill is driven by a constant horsepower adjustable speed Kraemer set, which gives the mill a delivery speed of 520 to 870 ft. per minute when finishing from stand No. 12. A Richardson-Phoenix oiling system, located under ground in the 1,500-hp. motor room, supplies oil to all shafting, gear and spindle bearings.

Exceptionally Heavy Motor Construction.

The main rolling mill drive motors with their control were supplied by the Allis Chalmers Manufacturing Company. These motors are located in two motor rooms, separate from the mill. The roughing mill motor is rated 1,500 hp., 78.5 rpm., 2,200 volts, 3 phase, 60 cycles. It is of the wound rotor induction type with base and two pedestal bearings. See Fig. 3. This motor is located between stands 4 and 5 and drives the mill through both ends of the shaft. The motor has very rugged construction and is especially adapted for heavy steel mill service. The yoke has a very deep section and rigidly supports the core by means of dove-tails integral with the punchings and heavy end clamps. The stator coils are diamond shape form wound, insulated with 4,000-volt Class A insulation. The coils are securely lashed and braced in place to prevent distortion under heavy overloads or when the motor is plugged. The rotor spider has I-beam section arms. The rotor core has a construction similar to that of the stator. The motor bearings are of the heavy mill type. They are spherically seated, ring oiled. A self-oiled thrust-bearing is located inside of each pedestal. The mill is driven through breaker spindles at each end of the motor shaft. the use of a direct coupled slow speed motor eliminates gearing and simplifies the entire layout. A lower maintenance expense and a higher over-all efficiency is obtained than if a high speed motor and a gear reduction set are used.

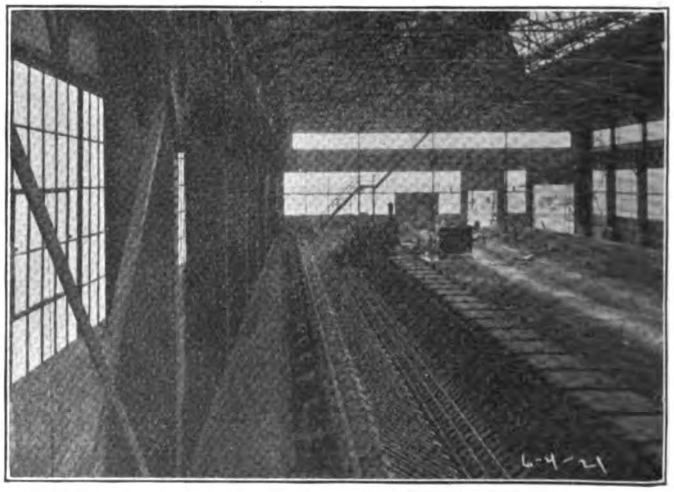

FIG. 2—VIEW OF COOLING BEDS

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*Chief Electrician, Inter-State Iron & Steel Company, South Chicago, Ill.

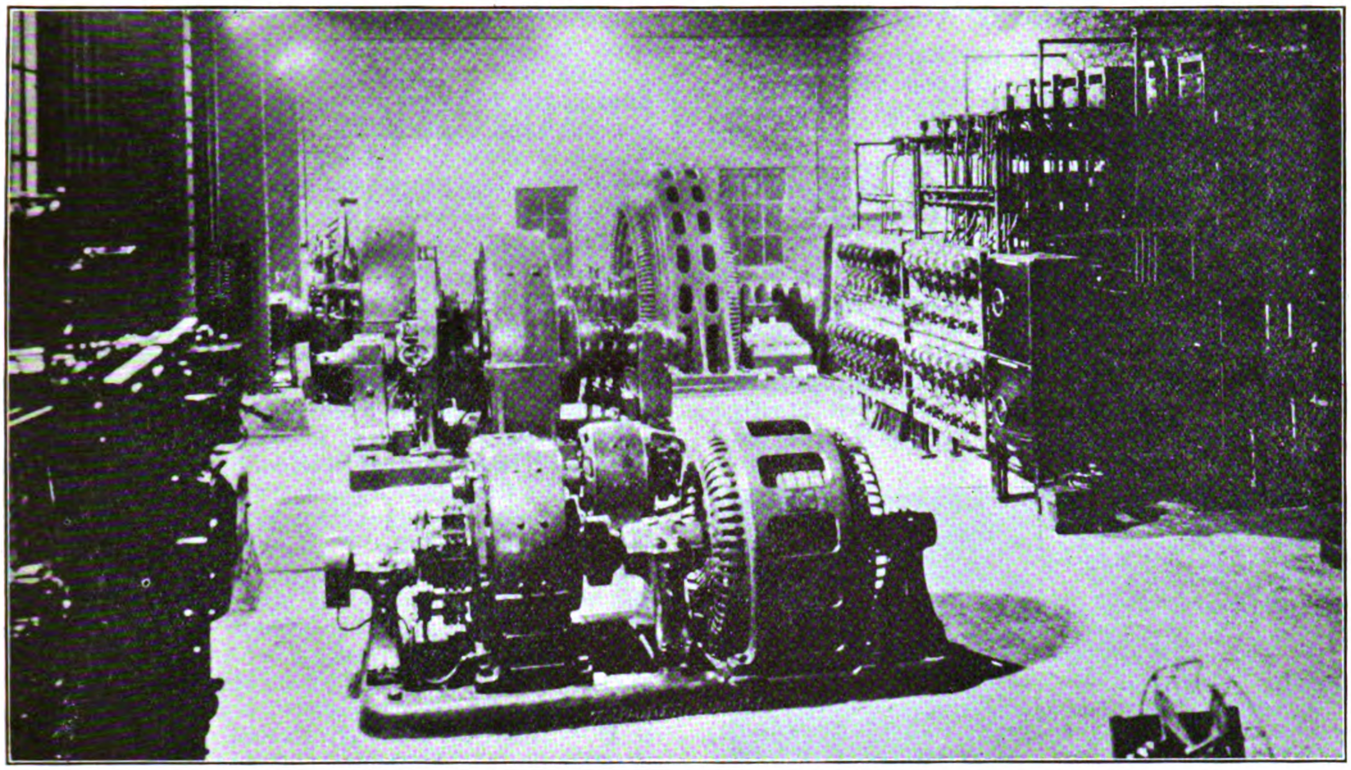

FIG. 3—MAIN ROLLING MILL MOTORS AND CONTROLS

The motor is provided with a split frame and a sliding stator. The finishing mill motor (Fig. 3) is rated 2,000 hp., 252 to 150 rpm., 2,200 volts, 3 phase, 60 cycles. The motor is direct coupled and belted to the finishing stands, and has the same details of general construction as the roughing mill motor. All bearings are provided with water cooling. This feature is not being used, however, for the bearings are so liberally proportioned that it is not required. A Spray Engineering Company air washer is located between the two motor rooms and supplies 25,000 cu. ft. air under two in. static pressure to the motor pits.

Motor Controls.

The control supplied with these motors is the direct current operated magnetic type arranged for plugging. The control panel with resistance is located adjacent to each motor. The master switches controlling both motors are located in the finishing mill motor room. Emergency stop buttons are located out in the mill. The motors are rated on the maximum continuous 50 deg. basis. They are continually called upon to carry sustained loads in excess of their ratings and frequently have carried peak loads in excess of their guaranteed maximum torque.

The cooling bed (Fig. 2) together with the hot runout table were designed and built by the Morgan Construction Company.

The 93 rollers on the hot runout table are individually driven by a General Electric ¼ hp. Squirrel Cage motor. The speed of these motors are controlled by a General Electric adjustable frequency motor generator set, capable of delivering any frequency between 26 and 14 cycles and voltage 110 to 67 volts. This gives a motor speed range on the hot bed rolls of 390 to 210 rpm.

The 33 rollers in the table from finishing mill to cooling bed are the standard cylinder type. The 60 rollers throughout the length of the cooling bed are of the cone type. Each cone roller and its motor is so pivoted that the angle of the roll can be changed in such a way relative to the direction of the motion of the bar, that the latter will ride on the large or small diameter of cone roll as desired.

The adjustable frequency motor generator set is located in the finishing mill motor room, where the motor attendant can adjust the speed for the small motors according to the speed required on the finishing mill motor.

Auxiliary Motors.

All auxiliary motors except those on the hot runout table are 230 volt direct current and were supplied by the Westinghouse Electric & Manufacturing Company. All reversing motors are the M.C.A. type and the nonreserving are type S.K., semi-enclosed. All auxiliary motor control is of the full magnetic type, manufactured by the Rowan Controller Company. All control equipment is concentrated in three balconies, one of these balconies also being used as the operating pulpit for the table and transfer operators.

There are two 15-ton 100 ft. span overhead electric cranes in the mill building, and a 10-ton 80 ft. span crane, equipped with magnet for handling billets is used in the billet storage yard which is adjacent to the mill furnaces. All cranes were furnished by the Morgan Engineering Company.

Power.

Power is purchased from the Commonwealth Edison Company at 12,000 volts. Three 1,667 kva., single phase General Electric transformers step the voltage down to 2,300 volts. Direct current for the auxiliary motors and cranes is supplied by two General Electric 500 kw., 900 rpm. motor generator sets. A 100 kva., 2,300 to 110 volt bank of transformers takes care of the lighting, 500 and 1,000 watt type C lamps in deep cone reflectors being used.

NEW SAFETY RECORD ACHIEVED

An outstanding feature in the American iron and steel world during the past month was the announcement of the developments in safety engineering achieved by the Edgar Thomson Steel Works, the Braddock plant of Carnegie Steel Company, who were awarded the Carnegie Steel Company's safety trophy for accident prevention during 1922. The trophy was awarded on a competitive basis, each plant competing with its own former accident rate. On this basis, Edgar Thomson Works achieved an accident reduction figure of 85.53 per cent, against the next best mark of 93.10 per cent reduction, made by the Duquesne Works. The Braddock "News Herald" in commenting on the local plant's achievement, claims additional prestige for the Edgar Thomson plant for the reason that "Edgar Thomson was already, at the beginning of 1922 safety race, the safest plant in Carnegie Steel."

EDGAR THOMSON WORKS - 1922.

Chief Safety Committee of the Edgar Thomson Works and the bronze safety trophy which was won by them in the Carnegie Steel Company Safety Contest for 1922.

Top row, left to right—O. J. H. Hartsuff, general superintendent; John F. Lewis, assistant general superintendent; F. F. Slick, operating superintendent; H. R. Hunter, W. A. Drylie, John B. Trusel.

Second row—Dr. O. H. Mehl, Frank A. Power. Harry J. Sparr, J. W. Forsythe, George Edmunds, E. S. Wright, James Callan.

Third row—J. R. Hunter, Charles LeBreton, David Scott, F. H. N. Gerwig, J. R. Evans, T. H. Graham.

Front row—George Small, T. H. Dailey, James B. Ball, D. R. Ferguson, H. R. James, John Lloyd, James Morgan and Jos. A. Lawler.

While the most pleasing features of the victory for the Edgar Thomson safety organization probably consist in the possession of the Minotti bronze safety trophy and the knowledge that it was won under conditions that really constituted a handicap (the plant was already the safest plant in Carnegie Steel at the commencement of 1922), the interesting fact for the iron and steel work is in the accident rate achieved. What can be achieved at the Braddock steel plant, with its diversified operations covering every phase of iron and steel manufacture, from the crude ore to the finished iron and steel products, can be accomplished everywhere. Edgar Thomson methods of safety organization and propaganda furnish standards of comparison well worth adoption.

In one of the latest and most complete governmental reports on the subject obtainable, Senate Document No. 110, the average fatality rate for a total of 155 steel plants in this country is given as 1.86 per thousand workers per year. The figures given for the large Edgar Thomson plant, with its numerous foreign employees, is 0.4 or an improvement of about 80 per cent over the official average. The government statistics for lost time accidents per thousand workers per annum in the 155 steel plants show an average of 240.6 per thousand workers. The figures for 1922 at Edgar Thomson show the astounding reduction of about 97 per cent in this figure, the accident rate being 7.8 per thousand.

The secret of the phenomenal success in safety achieved at Edgar Thomson Work's lies in securing the co-operation of every employee as well as every superintendent and department head. The entire plant has ben organized into some 17 safety committees, which meet regularly to consider ways and means of improving the safety of the plant and its operations. The safety work of the plant is under the supervision of John B. Trusel, Superintendent Safety and Welfare, assisted by the following men who form the chief safety committee of the plant: O. J. H. Hartsuff. General Superintendent; John F. Lewis, Assistant General Superintendent; F. F. Slick, Operating Superintendent and chairman of the main safety committee; D. R. Ferguson, W. A. Drylie, Joseph A. Lawler, David Scott, H. R. Hunter, J. R. Evans, John Lloyd, E. S. Wright, J. A. Morgan, J. W. Forsythe, F. A. Power, Charles W. LeBreton, James B. Ball, George Small, F. H. N. Gerwig, James C. Callan, H. R. James, J. R. Hunter, Dr. O. H. Mehl, Capt. T. H. Dailey, Harry J. Sparr and George Edmunds.

The safety organization contains members from every position and the rank and file of the plant are encouraged to present suggestions or recommendations for safety. Figures show that the 17 safety committees, together with their sub-committees, held a total of 532 meetings during the year on this subject.

The achievements at Edgar Thomson show conclusively that it is possible to make iron and steel plants as safe as any other industry. The whole answer to the problem lies in constant watchfulness and securing the thorough co-operation of the force.

JAPANESE STEEL AND IRON IMPORTS INCREASE

Nearly Twice as Much in Ten Months of 1922 as In Same Period of 1921—Pig-iron, Plates and Sheets, Rails and Semi-finished Products Chief Items.

Imports of iron and steel into Japan during the first 10 months of 1922 were 1,305,633 tons. During the corresponding period of 1921 only 718,441 tons were purchased from foreign countries. This 82 per cent increase was effected although stocks on hand in Japan were very large. Two factors that contributed to this increase, says Luther Becker, chief of the Iron and Steel Division of the Department of Commerce, were the placing in the Japanese market of large quantities of Indian pig iron at prices that domestic blast furnaces could not undercut, and the quickening of competition from German iron and steel producers.

Pig iron, plates and sheets, bars, rods, angles, and rails are the leading articles of importation.

The United States, Germany, Great Britain, China, British India, Kwantung Province (South Manchuria) and Belgium were the most important sources of these imports.

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Relation Between Width of Coke Oven Chambers and Coking Time*

By A. RUEHL

THE relative coking time of equally heated coke ovens depends on the quantity of coal opposite a unit of heating surface in the oven and on the heat passage between this unit of surface and the point of lowest temperature which will be midway between the two walls.

The wider the chamber of an oven, the larger is the quantity of coal deposited opposite the unit of surface. With equal heating surfaces in two ovens of different width, the quantities of coal to be carbonized are proportional to the width of the chambers. The larger the quantities of coal are, the higher the consumption of heat for the carbonization. With equal quantity of heating gas per time unit and with equal areas of heating surface the time of carbonization is in direct proportion to the content or to the width of the oven.

The relation of the coking time to the width of the oven, therefore, requires some explanation.

In a coke oven the wet coal is a body, which absorbs the heat intensively, while the resulting coke only receives the heat by transmission. During carbonization the size of the heat stream, that is the quantity of heat absorbed per unit of surface and time is dependent not only on the thickness of the brick wall, but also on the mean width of the layer of coke, which gradually forms itself.

Two ovens of equal height and length, but of different width of chambers may be filled with the same kind of coal and receive equal quantities of heating gas. The width of one oven may be $b_1 = 19.68''$; of another $b_2 = 15.75''$. If the charge of the larger chamber = a t, the one of the narrow chamber is $= a\ t \dfrac{15.75}{19.68}$

The actual heat consumption per ton of coal may be in each case 20 Btu. Further let:

$t\ a_1$ = the mean temperature of the heating wall in the wider chamber.

$t\ a_2$ = the mean temperature of the heating wall in the narrow chamber.

$t\ o$ = the mean temperature of the tar in course of Carbonization.

F = the heating surface, which may be equal for both chambers.

Z_1 and Z_2 = the time of coking in both chambers.

d_1 and, d the mean distance the heat must travel, consisting of the thickness of heating wall, and the mean thickness of the layer of coke in course of coking.

km_1 and km_2 = the mean coefficients of heat transmission, belonging to the temperatures ta_1 and ta_2.

Then $km_1\ (ta_1 - t_0)$ and $km_2\ (ta_2 - t_0)$ are the heat streams, referred to the units of surface, time and passage of the head.

The heat passing through the chambers results from the equation

$$(1.)\qquad \frac{km_1\ (ta_1 - t_0)\ F.Z_1}{d_1} = \text{w. a. Btu.}$$

$$(2.)\qquad \frac{km_2\ (ta_2 - t_0)\ F.Z_2}{d_2} = \text{w. a. } \frac{15.75}{19.68}\text{ Btu.}$$

For example some figures may be used in these quotations. The time of carbonization of the oven of 19.68" width may be 28 hours based on experience with ovens of fireclay brick and a humidity content of 10-11 per cent for the coal. The mean thickness of the brick wall may be 5.12" at the oven of wide chamber and 4.72" at the other.

Then the mean heat passage for the wide chamber is

$$(3.)\qquad d_1 = 5.12 + \frac{9.84}{2} = 10''$$

$$d_2 = 4.72 + \frac{7.87}{2} = 8.63''$$

and

$$\frac{km_2\ (ta_2 - t_0)\ Z_2\ .\ 10}{km_1\ (ta_1 - t_0)\ 28\ .\ 8.63} = \frac{15.75}{19.68}$$

From experiments, which are comfirmed by practical operation, the coking times at equal transmission of heating gas per time unit and oven are proportional to the charges or widths of chambers. In case the same quantity of heating gas per time unit is admitted to the wide as well as to the narrow oven with equal heating surfaces it follows that, $Z_2 : 28 = 15.75 : 19.68$ and from equation 3 results

$$(4.)\qquad \frac{km_2\ (ta_2 - t_0)\ 10}{km_1\ (ta_1 - t_0)\ 8.63} = 1$$

or

$$(5.)\qquad \frac{km_2\ (ta_2 - t_0)}{km_1\ (ta_1 - t_1)} = \frac{8.63}{10}$$

or

$$(6.)\qquad km_2\ (ta_2 - t_0) < km_1\ (ta_1 - t_0)$$

and

$$ta_2 < ta_2$$

The mean temperature of the heating surface is therefore lower in the narrow chamber than in the wider one. The heat stream in the narrow and in the wide chamber are in proportion to each other as 8.63 is to 10, that is, as the mean heat passage in course of carbonization.

The question now is; how is the coking time changed by raising the quantity of heating gas per time unit until the mean wall temperature of the nar-

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*Translated from Gluckauf of September 9, 1922, by H. Illies.

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row chamber equals the mean temperature of the wide one.

$$ta_2 \text{ is then } = ta_1 \text{ and } km_2\ (ta_2 - t_0) = km_1\ (ta_1 - t_0)$$

From equation 3

$$\frac{10\ .\ Z_2}{8.63\ .\ 28} = \frac{15.75}{19.68} \text{ or } Z_2 = \frac{13.75\ .\ 8.63\quad 28}{19.68\ .\ 10} = 19 \text{ Hrs.}$$

As S = thickness of the firebrick:

$$Z_2 = \frac{b_2\ [s_2 + (b_2 \div 4)]}{b_1\ [s_1 + (b_1 \div 4)]}\ .$$

$$Z_1 = —\ .\ \frac{s_2 + (b_2 \div 4)}{s_1 + (b_1 \div 4)}\ .\ Z_1 \text{ Hrs.}$$

If two coke ovens have the same wall temperatures the coking time of the one chamber in comparison with the known coking time of a wider or narrower chamber with equal heating surfaces is in proportion to the width of the chambers and to the mean heat passage during carbonization. Since the expression of the heat passage S + (b ÷ 4) includes the thickness of the firebrick in the heating wall, the relation of dependency of the coking time to the thickness of this brick has been taken into account. The following table shows a series of observations taken from actual operation during 12 years in the Ruhr district. The coking time amounted to 28 hours (operating time, 28.5 hours), the width of the chamber was 19.68 in. and the mean thickness of the heating wall was 5.12 in. In the latest quick coking ovens the bricks are only 4.72-in. thick. The coking time of ovens of equal height and length, but with different width of chambers and in which the supplied quantities of heating gas during a time unit produce equal high mean temperatures of the heating surfaces, are compiled in Table I. The water content of the coal was 10-11 per cent.

TABLE I — COKING TIME OF OVENS OPERATED AT EQUAL HEAT

Width of Chamber	Thickness of Firebrick Wall	Real Coking Time Hours	Operating Time Hours
19.68"	5.12"	28	28.5
17.71"	4.72"	23	23.5
15.75"	4.72"	19.3	19.8
14.56"	4.72"	17.3	17.8
13.38"	4.72"	15.3	15.8

In ovens of different width but equal heating surfaces and with uniform quantity of heating gas per unit and oven naturally the coking time varies only in proportion to the width of chamber. Of course, in narrower chambers the mean wall temperatures are lower than in wider ones. In narrower ovens with equal heating surface, the quantity of heating gas per time unit can be larger than in ovens of normal width of chambers without increase of wall temperatures and without the necessity, of the firebricks being exposed to higher temperatures than in ovens of a width of 19.68-in. Higher wall temperatures may be expected in narrow ovens only when the ratio of the increased to the normal quantity of heating gas per time unit exceeds the value of the inverted ratio of the heat passages.

By increasing the quantity of heating gas in the time unit to the inverted ratio of the heat passages the coking time in fireclay brick ovens can be made as low as in silica brick ovens without damaging the fireclay by the heat more than was customary in ovens of above dimensions 12 years previously.

The better heat transmission of the silica bricks against the clay bricks is not proven by the short coking times in silica ovens as is often supposed. If the works which manufacture firebricks succeed in rendering to the fireclay brick the mechanical properties of the silica brick, the fireclay brick would be preferable to the silica brick, because the fireclay brick with its content of clay does not have the disagreeable property of expansion and because the raw products are more easily procured.

In Table II is given the quantity of coal per oven in 24 hours and the necessary number of chambers for a daily capacity of 1,000 tons dry coal at different widths of chambers and coking times. The length of the ovens between doors may be 33.45 ft., the height of coal in the chamber 8.28 ft. and the specific weight of the coking coal 0.75.

It is obvious, that the coal capacity is increased or decreased by changing the height or length of the ovens in proportion to the heating surfaces. The ratio of the coking times to the width of the chambers is not affected by it.

TABLE II—RELATION OF OVEN-CAPACITY TO WIDTH OF CHAMBER

Width of Chamber 6in Inches	Mean Thickness of Brick of the Heating Wall in Inches	Coking Time in Hours	Operating Time in Hours	Content of Oven, Tons	Carbonizing Capacity of one Oven in 24 Hrs. Tons	Required Number of Ovens for 1,000 Tons in 24 Hrs.
19.68	5.12	28	28.5	10.2	8.6	116—118
17.21	4.72	23	23.5	9.2	9.2	109—110
15.75	4.72	19.3	20	8.2	9.8	102—103
14.56	4.72	17.3	18	7.6	10.1	99—100
13.36	4.72	15.3	16	7.0	10.5	95—96

BRITISH STEEL TRADE IMPROVING

The British iron and steel trade closed the year at the best level reached in 1922, and much encouraged by lessened competition from the Continent, larger overseas demand, and better prospects for the main domestic users, such as railroads, shipyards and engineering works. These branches of industry, although still operating at small part of capacity, are reported by Commercial Attache W. S. Tower, to the Department of Commerce, as being about to restart plants have remained idle since last Spring.

STEAM POWER DEPARTMENT

Determining Boiler Operating Factors

Discussion of the Methods Used to Determine the Essential Factors for the Economical Operation of Boiler Rooms—Results of Tests Given—Method of Calculating Combined Efficiency of Furnace and Grate Explained—Operating Charts Verify Points.

By D. C. HESS*

RECENTLY there has been a radical change in the method of operating boiler plants equipped with underfeed stokers. There were times when it appeared to be common practice to drive all the boiler units in service at their maximum rating without regard for operating economy or maintenance costs. There are times in the average boiler plant when the sudden demand for steam requires that the boiler be operated at high ratings over the peak load periods. However, continued operation at high ratings for long periods has generally been recognized as not good engineering practice because of subsequent low operating efficiency, economy and increased expense of maintenance.

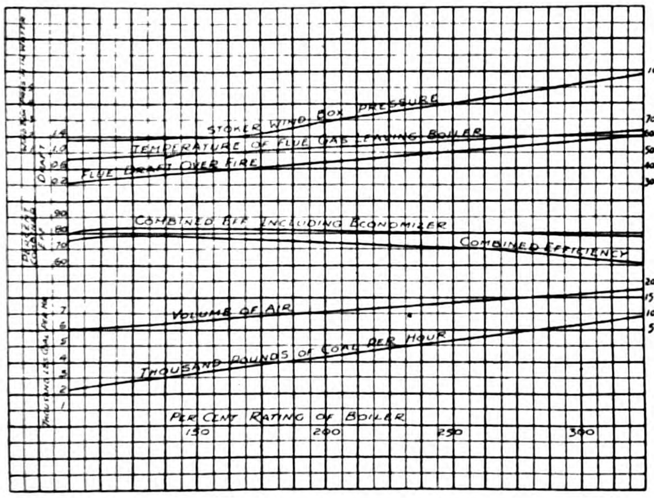

FIG. 1

Performance curve of a six-retort Westinghouse underfeed stoker firing a 558-hp. boiler.

Combustion Rates and Efficiencies.

There is a certain combustion rate where the stoker and boiler operate at their highest efficiency. This can be determined by running a series of short tests at various rates of combustion, and, therefore, an effort should be made to run as near this point as possible. However, usually this can not be done because, in case of a new plant, the designing engineers have to consider various elements such as first cost, labor, etc. In the case of old installations, it will often be found that the load demand upon the station has outgrown the station, with resultant high capacities. In this discussion it should be considered that the plant will operate at the highest efficiency point, for if the plant operates at any other point, the same discussion holds good, but in a lesser degree.

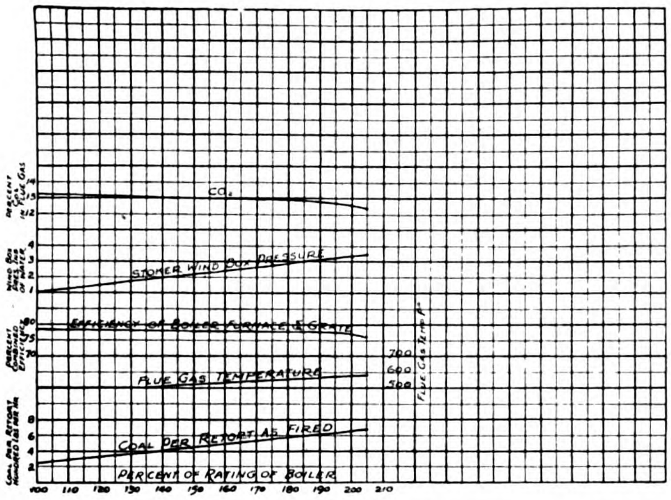

FIG. 2

Performance curves of a seven-retort Westinghouse underfeed stoker firing a 650-hp. boiler.

Fig. 1 shows the result of a series of tests using Illinois coil in a 6-retort Westinghouse underfeed stoker and a 558-hp. boiler. The grate area was 105.66 square feet. A rating of 328 per cent was obtained. The unit operated most efficiently at 160 per cent of normal boiler rating, when burning approximately 3,300 pounds of coal per hour, 550 pounds per retort, or 31.2 pounds per square foot of grate surface.

Fig. 11 shows the results of a series of tests run with Pittsburgh District coal. Each 650-hp. boiler had a

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*Stoker Engineer, Service Department, Westinghouse Electric & Manufacturing Company, Philadelphia, Pa.

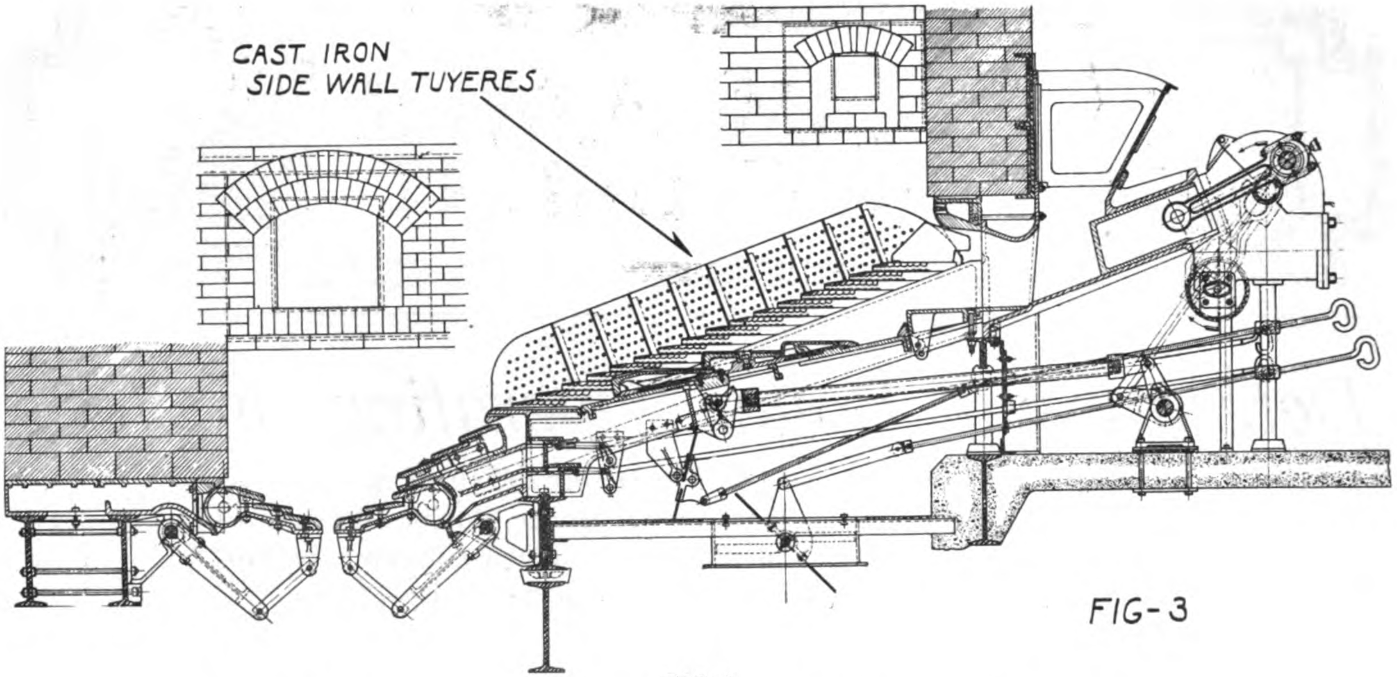

FIG. 3
A double dump moving grate 17-tuyere Westinghouse under-feed stoker with side wall tuyeres.

grate area of 123.27 square feet, which was supplied with fuel by a 7-retort Westinghouse underfeed stoker. The best efficiency was obtained at 185 per cent of normal boiler rating. It is also interesting to note the similarity between the combined efficiency CO_2 curves of this test. There was a gradual rise in the flue gas temperature as the boiler rating was increased.

Operating Deductions.

The results brought out by these tests show the essential conditions which are necessary to maintain the best operation of the stoker equipment. The point of highest combined efficiency for the first installation is 160 per cent of rating, while with the second equipment, the best efficiency was obtained between 170 and 185 per cent of rating.

The operating force in this plant has found that they can force this equipment to 328 per cent of rating if necessary. The condition of the furnace after a high rating test will determine the effects of the high temperature on the furnace walls and stoker parts.

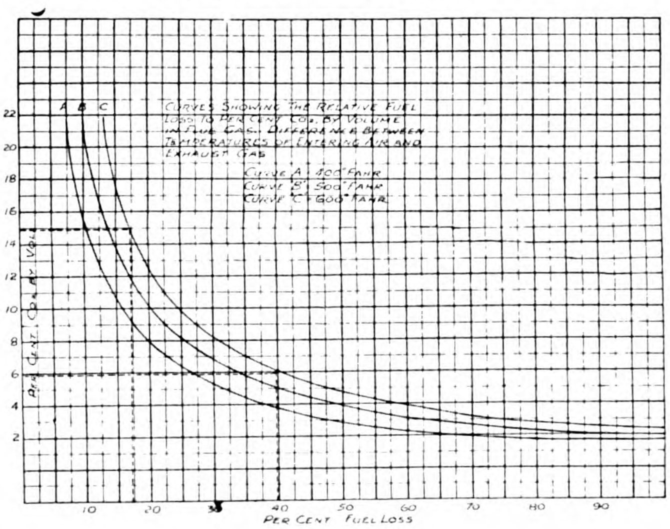

FIG. 4
Calculated CO_2 curves based on the per cent CO_2 by volume at flue gas temperatures of 400 deg. F., 500 deg. F., and 600 deg. F., with no carbon monoxide present. Shows fuel saving by increasing the CO_2 values.

Stoker Drive.

The type of stoker and fan driving equipment should be determined by the heat balance of the entire plant. If additional exhaust steam is required for feed water, engine or turbine drive will be preferable from an economy standpoint. On the other hand, if plenty of exhaust steam is available it might be preferable to use motor drive.

Prevention of Clinker Formation.

Clinker trouble is usually not so pronounced in most underfeed stoker installations until high ratings are reached, and high furnace temperatures are being maintained. If the coal being used contains a low fusing ash, it is evident that clinker trouble will be encountered. Clinker in the fuel bed is hard to avoid, and in cases where they do not move to the rear with the movement of the fuel bed, a hook or slice bar has to be used. Recent changes in the design of boiler bridgewalls tend to decrease furnace temperature and with it to some extent the formation of clinkers. This is accomplished by sloping the front surface of the bridgewall backward so that the rays of heat impinged upon it reflect directly into the boiler tubes and not back into the fuel bed. Also, the latest engineering practice is to expose all tube surface possible to the fire, thereby decreasing the furnace temperature.

In some plants side wall and bridge wall clinker troubles are avoided by the use of steam jets. On the other hand, many plants are using side wall tuyeres in connection with underfeed stokers. These side wall tuyeres are cast iron air boxes which extend above the side retorts and down along the side walls. They are rectangular in shape and fit closely together, but allow room for expansion and contraction. A large cored central space feeds air to the holes in the surface. The air issues at right angles to the wall or tuyere face. At plants where these side wall tuyeres are in use the side wall clinker trouble has been entirely eliminated, also the life of the boiler walls has been considerably increased. While the maintenance of the tuyeres is very low, due to air cooling the metal, stokers equipped with these tuyeres burn high ash western coals and low ash eastern coals equally well. Several furnaces have been in operation over three years with very satisfactory results. The air admitted through these side wall tuyeres has little or no effect on the CO_2 as the air is admitted below the surface of the fuel bed, and serves as an aid to complete combustion.

Fig. 3 shows an installation of the side wall tuyeres.

Instruments Aiding Efficient Operation.

Central station engineers are fully aware of the necessity for supplementing an expensive boiler plant with a few reliable instruments that are absolutely necessary for efficient and successful stoker operation. This does not mean that an elaborate set of instruments is necessary, but every boiler plant unit should be equipped with draft gauges for measuring the pressure of the air; in the windbox, in the combustion chamber and in the last pass or in front of the stack damper. A recording or indicating CO_2 apparatus is also desirable for close combustion regulation.

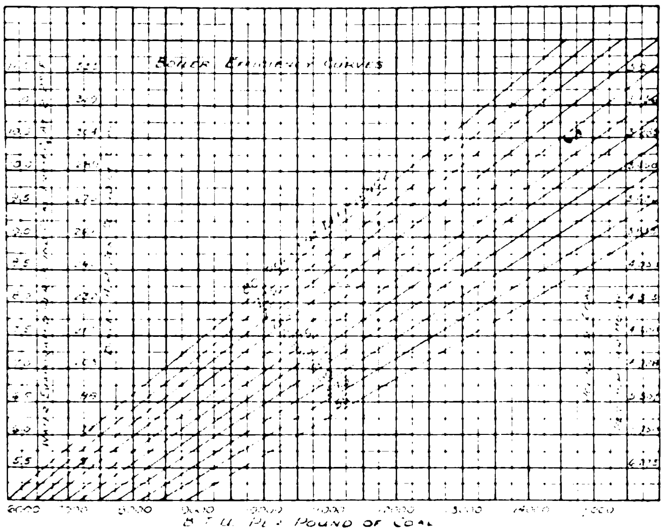

FIG. 5

Combined boiler efficiency curves based on pounds of water evaporated from and at 212 deg. F. per pound of coal, of various Btu. values.

Steam flow meters are extremely valuable boiler appliances. The use of such equipment gives a good check on the combined efficiency of the boiler and stoker.

The ability of the coal to ignite and burn readily in the grates is quickly determined by such actual operating tests. Moreover, such tests have repeatedly proven that very good results can be obtained from cheap coal. The proper ratio between the rate of coal feed and approximate air pressure for various grades of coal will be quite evident after a series of such tests, at different ratings.

Pyrometers are valuable for determining the flue gas temperature. A high stack temperature means that a relatively small amount of heat is being absorbed by the tubes. This is caused in most cases by defective baffling and dirty tube surfaces. Also a balanced draft in the combustion chamber decreases the infiltration of air through the setting, which is conducive to higher efficiency. Power plant engineers have taken time to study the theoretical side of combustion from its economy standpoint and have saved thousands of dollars each year in the fuel alone. They understand just what a two or three per cent increase in CO_2 means. Also, the greater evaporation per pound of coal by keeping the flue gas temperature at its lowest possible point. The result in dollars and cents has been most gratifying.

This emphasizes the advantage of the mechanical steam dump which aids the operator in cleaning the fires quickly. Dampers are provided on the dump grates of the stokers under consideration, to prevent an excess of air from being admitted up through the dump grates at cleaning periods. These dampers are opened to burn excess fuel on the dump grates, thereby increasing the combustion rate and reducing the carbon content in the refuse.

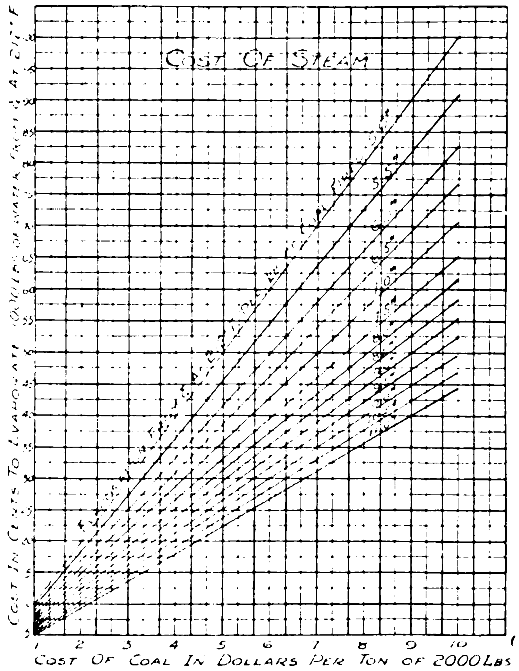

FIG. 6

Cost of steam based on the pounds of water evaporated from and at 212 deg. F. per pound of coal fired.

Three Factors for Firing Furnaces.

The principal final product of complete combustion of fuel is carbon dioxide (CO_2). In order to obtain high CO_2 the most important factors to take into consideration are:

First, keep the fuel bed in good condition. That is, prevent the formation of holes in the fire. Maintain the correct thickness and contour of the fuel bed.

Second, eliminate all air leaks in the boiler walls.

Third, maintain as nearly as possible a balanced draft or a slight vacuum in the combustion chamber. Avoid bottling up the gases which would cause a pressure in the furnace. Such a pressure would be very destructive to the brickwork and stoker parts. One type of baffle graduates the cross section of the flue gas passage, so that the velocity of the gas will be uniform throughout the boiler and also eliminate any dead pockets where there is no circulation of gas.

Importance of High CO_2.

Fig. 6 is a calculation curve based on the CO_2 per cent volume of flue gas temperatures of 400 deg. F., 500 deg. F., and 600 deg. F. with no carbon monoxide. Theoretically, perfect combustion of pure carbon will give 20.7 per cent of CO_2 in the flue gases. However, perfect combustion is not possible in boiler room practice.

Referring now to Fig. 6, suppose the flue gases analyze 6 per cent CO_2 and that by decreasing the amount of excess air and giving careful attention to the fuel bed the CO_2 is increased to 15 per cent. A glance at the curves shows that the relative fuel loss has been reduced from 40 per cent to 17, which amounts to a fuel saving of 10 to 12 per cent.

Determining Combined Efficiency.

The general definition of the efficiency of an apparatus is the ratio of the energy developed by the apparatus to the energy available for its use.

The efficiencies of the different parts of a boiler installation and of the installation as a whole are defined in so many ways that there is frequently confusion. The following defintions are recommended:

What is ordinarily called the efficiency of the boiler is in reality the combined efficiency of the boiler, furnace and grate, and is the heat absorbed per pound of fuel divided by the heating value per pound of fuel. The value obtained will be approximately the same whether the efficiency is based on dry fuel or fuel as fired. All the fuel is not burned, some of it goes through the grates or is dumped out with the ash while cleaning the fire. It is obviously unfair to charge this loss to the boiler. On the other hand, the boiler user must pay for it and is justified in charging it against the furnace.

The combined efficiency can be expressed as

$$E = W\,(h+L+sS-f)\,/DH$$

Where W = Lb. of water evaporated in a unit of time.
D = Lb. of coal fired in a unit of time.
s = .48 = Specific heat of steam.
h = Heat of liquid at steam pressure.
L = Latent heat.
S = Degree supt.
$h+L+sS$ = heat in 1 lb. of steam as delivered by boiler.
f = heat in 1 lb. of water as received by boiler.
H = heat value of 1 lb. of coal in Btu. as fired.

The enumerator of the above fraction equals 970.4 Q, where Q is the factor of evaporation.

Specimen Heat Balance.

A typical heat balance worked out according to the above formula is given below:

The calculations are made as follows:

24-Hour test of 2400 hp. boiler operated at 137 per cent of rating.
Coal as fired: 76.87% Carbon: 5.31% Hydrogen; 7.19% Ash; 1.80% Moisture; 13,810 Btu. per lb.
Dry coal = 98.2% of coal fired.
Dry coal basis: 78.30% Carbon; 7.32% Ash; 5.41% Hydrogen; 1.83% Moisture; 14,090 Btu. per lb.
Coal fired 246,000 lbs. = 241,500 lbs. dry coal.
Refuse produced 21,375 lb. = 8.88% of dry coal.
Carbon in refuse = 8.88 — 7.32 = 1.56% of dry coal.

This statement assumes that all of the ash is in the refuse.

Flue gas analysis: 14.6 per cent CO_2, 0.36 per cent CO, and 3.30 per cent O_2. CO is seldom found in the products of combustion, but if produced it is treated as follows in the heat balance:

160 lb. gauge, super heat 100 deg. = 1254 Btu. per lb. above 32 deg. F.

Average temperatures: Feed water 220 deg. F., flue gas 560 deg. F., room 72 deg. F., air 63 per cent saturated.

HEAT BALANCE CALCULATIONS

	Btu. per lb. dry coal	Per cent of total heat
1. Heat absorbed by boilers: 2,480,000 (1254—[220—32])/241,500	10,960	77.79
2. Heat lost by evaporation of moisture in coal: 0.0183 (212—72+970+0.47[560-212])	23	0.16
3. Heat lost in steam from hydrogen in coal: 9 x 0.0541 x (212—72+970+0.47[560—212])	609	4.32
4. Heat lost in dry flue gases: Air = 3.036 (0.7830—0.0156) (1—0.1460—0.0036—0.0330) / (0.1460+0.0036) = 12.45 lb. per lb. of dry coal; Gases 12.45 + (1—0.0888) = 13.36 lb. per lb. dry coal. Loss = 0.24x 13.36 (560—72)	1565	11.10
5. Heat lost in unburnt CO = (0.7830 x 10, 150 x 0.0036) / (0.1460 + 0.0036) = ...	193	1.37
6. Heat lost in combustible refuse = 14,600 x 0.0156 = ...	246	1.75
7. Heat lost in heating moisture in air = 63% at 72° F. = 0.0168 x 0.63 = 0.0105 lb. per lb. of air (0.0105 x 12.45 x 0.46[560—72]) = ...	29	0.21
8. Unaccounted for (radiation, unburned hydrocarbon, errors of observation) by difference = ...	465	3.30
Total.............	14,090	100.00

Fig. 7 is a set of curves showing combined efficiencies based on pounds of water evaporated from and at 212 deg. F. per pound of coal of various Btu. values. These curves also give the boiler horsepower per pound of coal and pounds of coal per horsepower per hour.

Cost of Steam Curves.

Fig. 8 is a set of curves showing the cost of steam based on the pounds of water evaporated from and at 212 deg. F. per pound of coal fired. The column at the left shows the cost in cents to evaporated 1,000 pounds of water which is plotted against the cost of coal in dollars per ton of 2,000 pounds.

"The Three Graces."

After you have made a thorough study of your boiler room conditions and heat balance, you will no doubt come to a final conclusion that the economical operation of your boiler plant narrows down to three things:

First, *Maintaining High CO_2*. This means good combustion of the fuel. This is accomplished by keeping the proper ratio between the fuel bed and air supply, good fuel bed conditions and careful attention to the operation of stokers and boilers.

Second, *Keeping the Flue Gas Temperature as Low as Possible*. That is, absorb all the heat possible from the furnace gases before they reach the breeching.

Third, *Reducing the Combustible in the Refuse as Low as Possible*. This signifies good operation on the part of the fireman who should control the fuel bed conditions so that a minimum amount of carbon is dumped with the ash.

These three items are the main factors in boiler room operating from an economy standpoint.

HEAT TREATMENT OF STEEL IN OIL INDUSTRY

F. B. Foley, metallurgist of the Bureau of Mines, and Prof. C. Y. Clayton, of the Missouri School of Mines, have visited oil fields of Oklahoma, Texas, and Louisiana for the purpose of observing methods of sharpening and handling tools and drill bits in oil well drilling. The manufacturing plants of several oil well supply companies were visited and their methods of handling drill steel were observed. The Bureau of Mines is undertaking a general study of the drill steel problem in the oil industry.

Automatic Skip Hoists for the Handling of Coal and Ashes

Types of Skip Hoists, Motors and Controllers for Operating the Same—Controllers Have Been Carefully Standardized to Meet All Requirements and Hoist Can Now Truly Be Said to Be Automatic.

By H. W. STEVENS*

AUTOMATIC skip hoists for the handling of coal and ashes have practically become a necessity in power plants, steel mills, railroad coaling stations, or wherever large quantities of coal and ashes must be handled.

Development of both the mechanical and electrical portions of the equipment has progressed to the point where it is now possible to supply the proper combination of mechanical hoist and electric control to meet any installation condition, and in every case the operator has only to press a button to start the equipment, which will then hoist, dump, lower and load automatically until it is stopped by the operation of another push button.

Some of the most important installation conditions which affect the design of the equipment are, amount of material to be handled per hour, power available, location of loading point with respect to dumping point and method of operation.

Types of Skip Hoists.

There are three main types of skip hoists now in use. First, two bucket balanced hoist; second, single bucket counter-balanced hoist; third, single bucket unbalanced hoist.

The two bucket balanced hoist, as the name implies, is provided with two buckets, one being hoisted as the other is lowered, and under these conditions there is always a positive load to be hoisted, except in emergencies when a loaded bucket is lowered and an empty bucket hoisted.

The single bucket counter-balanced hoist is provided with a counterweight equal to the weight of the bucket, plus approximately one-half of the minimum load, so that for normal operation of this type of hoist, there is always a positive load to be hoisted and the power requirements are very similar to the two bucket balanced hoist. With this type of equipment, it is necessary to so arrange the counterweight that a portion of the weight will be taken off as the bucket approaches the limit during the dumping operation, as otherwise the counterweight will overhaul the motor and slowdown will not take place.

The single bucket unbalanced hoist has only a positive load while the load is hoisted, and during lowering of the bucket, it will overhaul the motor, the motor retarding the speed of the bucket and acting as a generator.

A typical skip hoist arrangement of the single bucket unbalanced type is shown in Fig. 1. With the two bucket balanced type, a double set of guides is required and the other hoisting cable is attached to the opposite end of the winding drum from the first one in the case of a drum type machine, or in the case ot a traction machine one bucket is attached to each end of the cable, which passes over the winding drum. On the single bucket counterweighted equipment, a small set of guides is required for the counterweight and the counterweight cable is attached to the winding drum in the same manner as for the double bucket equipment.

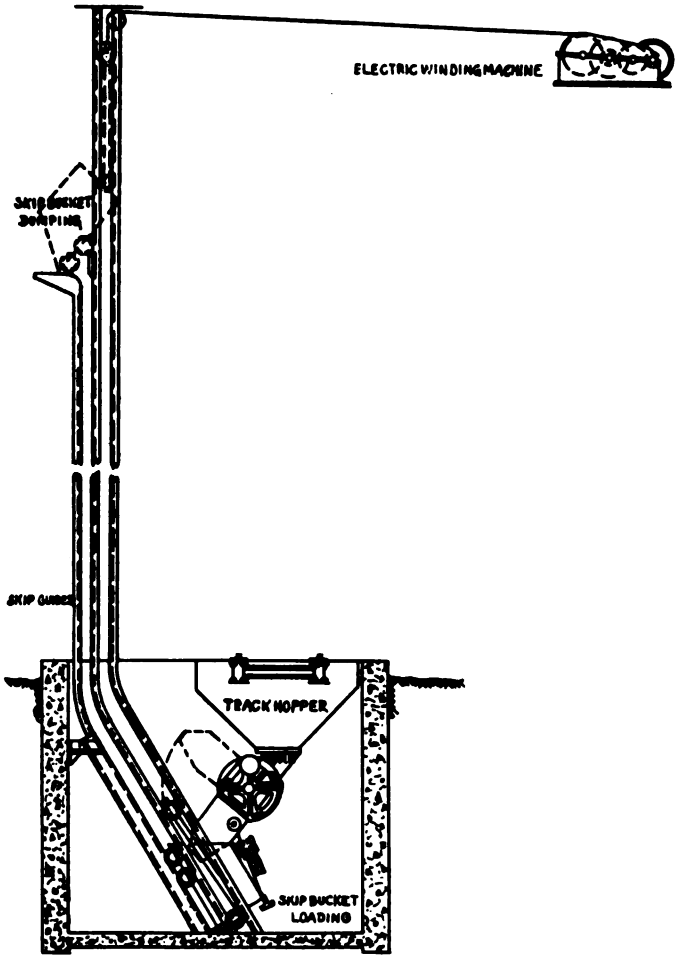

FIG. 1
A typical single bucket unbalanced skip hoist.

There are various types of buckets in use, but most of them can be placed in one or the other of two main classes. The first class includes all those which are so constructed as to dump during the slowdown period, so that by the time the bucket comes to rest, the load is completely dumped and the skip can be lowered at once. A typical bucket of this kind is shown in Fig. 1. The second class includes all those which cannot dump until they hace come to rest and therefore require an appreciable time for dumping. A typical bucket of this type is shown in Fig. 2. The dotted lines show the position of the sides in the dumping position. The sides cannot be lowered until the bucket has come to rest. On high speed hoists, even when buckets of the type shown in Fig. 1 are used, the slowdown period is so short that tthe coal cannot be completely dumped before the bucket comes to rest and a certain time element is necessary before lowering, althought this time is shorter than is necessary with the other type of bucket.

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*Engineer, Cutler Hammer Manufacturing Company.

The hoistway for the skips are either vertical, inclined or a combination of these two. The six forms shown in Fig. 3 will cover the majority of installation conditions to be met.

The hoisting machine used with skip hoists may be either of the drum or traction type. With the drum type machine, the cables for both the bucket and the counterweight are permanently attached to the drum, so that slippage of the cable cannot occur, while with the traction type of machine, the cable simply passes over the drum and power is transmitted by the friction between the cable and the drum. There are advantages and disadvantages for each type under certain conditions, some of which will be brought out below. When a traction type of machine is used, the limit switches are mounted in the hoistway and are operated by contact with the skip itself. This means that the guides must be accurate enough to make sure that the skip cannot fail to operate the limits and of course, means a more expensive construction than would be necessary otherwise. However, in case the skip or counterweight passes the overtravel limits, it has the advantage, the counterweight or skip will bottom and the winding drum can then continue to revolve without harm to the machine. Of course, the traction type can only be used with a balanced or counter-balanced type of skip hoist.

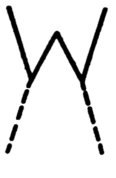

FIG. 2

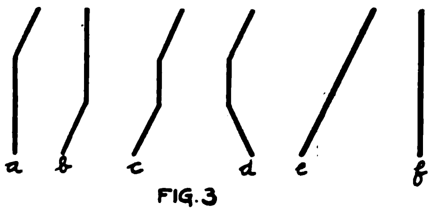

FIG. 3

FIG. 2

Illustrating the bucket which cannot dump until it is at rest. The dotted lines indicate the position of the sides in the dumping position.

FIG. 3

Showing six forms of hoistway that will cover the majority of installation conditions to be met.

When a drum type of machine is used, the limit switches are usually assembled into a unit, which is geared directly to the winding drum. The operation of the limit switches in this case is positive, but if for any reason the skip should fail to reverse at the limits, the cable would be pulled out or some other serious damage result to the winding machine. However, the chance of this occurring is fairly remote.

The drum type of machine seems to be more popular for skip hoist service than the traction type as it is used in the majority of cases.

The winding drum may be driven through spur gearing or through worm and worm wheel. The spur gear drive is the most efficient as far as power required is concerned, but is also probably the most expensive as it requires a train of cut gears which must be run in oil. With the worm gear drive, a thrust bearing is required and the wear is fairly rapid if the service is continuous, and due to the low efficiency of the worm, the power consumption is much higher.

Types of Motors.

In selecting the proper type of motor for any particular installation, the following points must be considered.

1. Power available.
2. Speed of hoist.
3. Type of skip hoist.

When direct current is available, either a compound or series motor may be used. A compound motor is ordinarily used with a two bucket balanced hoist or with the single bucket counterweighted, as under normal conditions there is always a positive load to be hoisted. The series field is usually cut out with the last step of accelerating resistance so that a constant speed is obtained for both hoisting and lowering.

A single bucket unbalanced hoist provides a positive load during hoisting only, while lowering of the bucket, it will overhaul the motor, which will tend to retard the load and act as a generator. For this service, a series motor with a dynamic lowering scheme of connection, is most suitable, as the motor will hold the bucket to a safe speed during lowering.

In case alternating current is available, either a single speed or a two-speed motor may be used. The single speed motor may be either of the high torque squirrel cage type, or of the slip ring type. If a two speed motor is to be used, it may be any one of five different types. First, a squirrel cage motor with a separate winding for high and low speeds. Second, a squirrel cage motor with one winding which is reconnected to give the two speeds. Third, a slip ring motor with a separate winding for high and low speeds. Fourth, a slip ring motor with one winding which is reconnected to give the two speeds. Fifth, a combination of two motors on one shaft, a slip ring motor being used to obtain high speed, and a squirrel cage motor to obtain low speed.

On slow speed hoists where the hoisting speed does not exceed 125 ft. per minute, a single speed high torque squirrel cage motor can be used satisfactorily, as no slowdown is necessary. This type of motor can be used with all three types of skip hoists.

On medium high speed hoists where the hoisting speed is not over 200 ft. per minute, a single speed slip ring motor can be used as at this speed 50 per cent slowdown, which can be obtained with a slip ring motor, is satisfactory. This type of motor can only be used with a two bucket balanced hoist or a single bucket counterbalanced hoist. This is due to the fact that with a single bucket unbalanced equipment the load is overhauling during lowering and no slowdown could be obtained. What should be used is the two speed high torque squirrel cage motor as this would give a definite slowdown even with an overhauling load.

On high speed hoists where the speed is between 200 and 300 feet per minute, any of the two speed motors can be used. The squirrel cage type should only be used in such sizes as would be satisfactory to throw across the line. On the larger sizes it is necessary to use the slip ring type of motor. This type also gives a more constant speed when operating on slow speeds.

The motors having two separate windings require a relatively simple type of control, but are large in size and have a very low power factor when operating on the low speed winding. This is due to the distribution of the windings, which is favorable for the high speed winding and unfavorable for the low speed. The reconnected type of motor is more compact and simple in construction as far as the motor is concerned. It requires a very complicated type of control to handle it properly.

A three to one speed range is ordinarily used with the two speed motors as this given a slow down speed of from 65 to 100 ft. per minute, with a running speed of 200 to 300 ft. per minute. However, this type of motor has been built for speed ranges as high as from 6-1, but such a wide speed range is not necessary with the ordinary skip hoist.

Skip Hoist Controllers.

Skip hoist controllers have been quite thoroughly standardized, and eight distinct types—four direct current and four alternating current have been found sufficient to cover the entire range of requirements. These are as follows:

Direct Current.

(1) Semi magnetic slow speed — for compound wound motors.

(2) Full magnetic slow speed — for compound wound motors.

(3) Full magnetic high speed — for compound wound motors.

(4) Full magnetic dynamic lowering — for series motors.

Alternating Current.

(5) Semi magnetic slow speed—for squirrel cage motors.

(6) Full magnetic slow speed—for squirrel cage motors.

(7) Full magnetic high speed—for slip ring motors.

(8) Full magnetic high speed—for two speedmotors.

The method of operation of any of the above types may be either non-automatic or automatic.

When the operation is non-automatic the hoist when started hoists one load and then stops, and in order to hoist another load it is necessary to again press the starting button. This means that in the case of the two bucket hoist the motor operates to hoist one bucket to the top and is then stopped automatically by the limit switch. In the case of the single bucket hoist, either counter balanced or unbalanced, the equipment hoists the bucket to the top, dumps the load and returns the bucket automatically to the bottom again and stops.

With automatic operation, however, the equipment continues to operate when the start button is pressed until stopped by the operator by pressing the stop button. That is, when this type of equipment is started it will hoist the load, stop automatically at the top by the limit switch and return automatically to the bottom until stopped by the limit switch, and will start automatically again. This will continue until the stop button is pressed.

For a non-automatic equipment where a time interval is required for dumping the load at the top, after the final limit is reached, some provision must be made for this time interval on single bucket hoists. This time interval is not required, however, on the two bucket hoist. In the case of the automatic type the bucket is automatically loaded when it reaches the order to allow sufficient time for filling of the bucket, so that with this type of equipment it is necessary to provide this time interval for both single and two bucket hoists. The time interval is obtained by the use of a timing relay.

Direct Current.

Type No. 1 is for use with compound wound motors operating hoists where the hoisting speed is not over 75 ft. per minute. The motor must be provided with a shunt wound holding brake.

The controller consists of an automatic starter, a drum reverse switch operated from the winding mechanism and a separately mounted push button station. The hoist is started from the push button station and stopped automatically from the drum reverse switch. The drum reverse switch cuts off the power and sets the brake but does not provide any slowdown before stopping.

The automatic starter contains a main line magnetic contractor and a time limit accelerating movement, a brake and field relay, and overload relay, a main line disconnecting knife switch and control fuses. In addition a timing relay is provided for automatic operation and also in case of a single bucket hoist when time is required for dumping.

The push button station in the case of the non-automatic equipment is provided with a start and stop button. In the case of the automatic equipment an additional button is provided for obtaining the automatic feature.

The semi-magnetic controllers are not as universally applicable and not so flexible in operation as the full magnetic, and it is not possible to stop the equipment and reverse the direction of operation, because the direction of operation is controlled from a drum reverse switch which is driven from the winding mechanism. Where it is desired occasionally to reverse the direction of operation before reaching the end of travel, a full magnetic controller must be used.

Type No. 2 which is a full magnetic slow speed equipment is used with compound wound motors operating skip hoists where the speed is not over 100 to 125 ft. per minute. The motor must be provided with a shunt wound holding brake.

The controller consists of an automatic starter, traveling cam limit switch driven from the winding mechanism and a separately mounted push button station. The hoist is started from the push button station and stopped automatically from the limit switch. The limit switch cuts off power and sets the brake and the controller is not arranged for any slowdown before stopping.

The automatic starter consists of four contactors for reversing the main line magnetic contactor, an accelerating time limit movement, a brake relay, and overload relay, a main line disconnecting knife switch and control fuses. In addition a timing relay is provided for automatic operation and also on single bucket hoists for non-automatic operation.

Type No. 3 which is a full magnetic high speed

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equipment is used with compound wound motors operating skip hoists for speeds up to approximately 300 ft. per minute. The motor must be provided with a shunt wound holding brake also. These controllers should be used with either two bucket hoists or single bucket counterbalanced hoists. They should not be used with single bucket unbalanced hoists. Type No. 4 should be used for this purpose.

The controller consists of an automatic starter, traveling cam limit switch driven from the winding mechanism, and a separately mounted push button station. The hoist is started from the push button and stopped automatically by the limit switch. The controllers are arranged for slowdown before stopping

The automatic starter consists of four contactors for reversing, main line magnetic contactor, an accelerating movement and an armature shunt contactor, a brake and field relay, overload relay, a main line disconnecting knife switch and control fuses. In addition a timing relay is provided for automatic operation, and also on single buckets for non-automatic operation.

Type No. 4, which is a full magnetic dynamic lowering equipment is for use with series wound motors, provided with series wound brake operating unbalanced skip hoists, where the hoisting speed is not over approximately 300 ft. per minute.

The controller consists of an automatic starter, a traveling cam limit switch geared to the winding mechanism and a separately mounted push button station. The hoist is started from the push button station and stopped automatically by the limit switch. The equipment can be arranged so that in case of a slow speed hoist power will be cut off and the brake set for stopping at the limit. Or in the case of hoists where the speed is over 100 ft. per minute they can be arranged to provide for slow-down before stopping.

The automatic starter consists of the necessary contractors for providing power and dynamic, a main line contactor, an accelerating time limit movement, an overload relay, a main line disconnecting knife switch and control fuses. In addition a timing relay is provided for automatic operation, also on single buckets for non-automatic operation.

Alternating Current.

Type No. 5, which is a semi-magnetic slow speed equipment, is for use with high torque polyphase squirrel cage motors operating skip hoists where the speed is not over 75 ft. per minute. The motor must be provided with a holding brake, either of the solenoid or torque motor operated type.

The controller consists of a control panel, a drum reverse switch operated from the winding mehcanism, and a separately mounted push button station. The hoist is started from the push button station and stopped automatically from the drum reverse switch.

The control panel contains a main magnetic contactor, a duplex time limit overload relay, a three pole disconnecting knife switch and control fuses. In addition a timing relay is provided for automatic operation, and also in case of a single bucket hoist where time is required for dumping.

The same statements can be made for the semi-magnetic a.c. controllers as was made for the semi-magnetic d.c., i.e., that they are not universally applicable and not so flexible in operation as the full magnetic, in that it is not possible to stop the equipment and reverse the direction of operation.

Type No. 6 which is a full magnetic slow speed equipment for use with high torque polyphase squirrel cage motors operating skip hoists where the hoisting speed is not over 100 to 125 ft. per minute. A holding brake must also be supplied with this type which may be of either the solenoid or torque motor operated type.

The controller consists of a control panel, a traveling cam limit switch geared to the winding mechanism and a separately mounted push button station. The hoist is started from the push button station and stopped automatically from the limit switch.

The controllers for single bucket hoists are all arranged to allow time for dumping of the load.

The control panel contains two magnetic double pole contactors for reversing and one main line double pole magnetic contactor, one duplex overload, a three pole main line disconnecting switch and two control fuses. The timing relay is also necessary as on the other equipments where automatic operation is desired, or for single bucket on non-automatic operation.

Type No. 7, which is the full magnetic high speed equipment, is for use with slip ring induction motors operating hoists where the hoisting speed does not exceed approximately 200 ft. per minute. The motor also in this case must be provided with a holding brake. These controllers should be used with either two bucket hoists or a single bucket counterbalanced hoist. For single bucket unbalanced hoists a type No. 8 equipment should be used with a squirrel cage type of motor.

The controller consists of an automatic starter, a traveling cam limit switch geared to the winding mechanism and a separately mounted push button station. The hoist is started from the push button station and stopped automatically from the limit switch. The limit switch is arranged to provide slowdown and cut off power.

The automatic starter consists of two magnetic double pole contractors for reversing, one magnetic two pole main contactor, an automatic time limit accelerating movement, a duplex overload relay, a three pole disconnecting switch, and control fuses. In addition a timing relay is provided for all hoists requiring automatic operation, and also on single bucket hoists for non-automatic operation.

Type No. 8 is a full magnetic high speed equipment for use with two speed motors. Anyone of the five types of a.c. motors described previously may be used, and the necessary contactors of course vary with the type of motor used.

The simplest type of control is required for the high torque squirrel cage motor having two separate primary windings. In this case all that is required is two double pole contactors for reversing, a main line contactor and two double pole contactors for connecting the high and low speed windings to the line. In addition a duplex overload, three pole main line knife switch and two control fuses are required. The timing relay for providing the time interval at the top is required under the same conditions as on the previously described controllers.

For motors of the slip ring type, having two separate primary and two separate secondary windings, the control is the same as for the squirrel cage with the addition of an automatic starter for cutting out the secondary resistor. Practically the same type of control can be used for the two motor unit having a slip ring high speed motor and a squirrel cage motor for slow speed.

For the two speed motor having the single squirrel cage winding which is reconnected to give the two speeds, at least three additional contactors are required in addition to the material for the motor having the two separate primary windings, and the control scheme in general is much more complicated than that required for the double winding.

For the two speed motor having the slip rin gwinding, and requiring reconnection for the two speeds, at least three additional contactors are required over the material necessary for the slip ring type having the two separate windings, and the control scheme is even more complicated than that required for the squirrel cage reconnected type.

While the control itself is more complicated for the reconnected type of motor, once it is properly installed it operates just as simply as the other types.

On all two speed motors the high speed winding is used for starting and running, the low speed winding being used for slowdown only. The limit switch is arranged to cut in the slowdown winding at the proper time and is set just enough in advance of the final limit to allow the speed to come down to the synchronous speed of the slow speed winding before the final limit is tripped.

When an a.c. motor is driven over synchronous speed it acts as a generator and requires power to drive it, depending upon the amount of speed above synchronism. This is the principle which is made use of in using two speed motors for slowdown purposes. At the same time the slow speed winding is connected to the line it is running about three times the synchronous speed of the low speed winding and it exerts dynamic braking effect until it comes down to its own synchronous speed at which time it again attempts to drive the load and there is no advantage in leaving it connected to the line any longer.

A particular advantage in the use of the two speed motors is the fact that a definite slow down speed will be obtained regardless of the load conditions. In fact even when the load is negative.

From the foregoing it will be evident that skip hoists have been developed to the point where they are truly automatic, that is, every function is taken care of without any thought on the part of the operator, and it is only necessary for him to press the button to start and another to stop, all intermediate steps being taken care of by the electric control or the mechanical hoist.

PROMINENT ENGINEER ELECTED CHAIRMAN PITTSBURGH SECTION OF AMERICAN CHEMICAL SOCIETY

Edward Ray Weidlein, chemical engineer and Director of the Mellon Institute of Industrial Research of the University of Pittsburgh, Pa., was born at Augusta, Kansas, July 14, 1887. He received the Bachelor of Arts degree from the University of Kansas in 1909 and the Master of Arts degree in 1910.

Mr. Weidlein was an Industrial Fellow engaged in research on camphor at the University of Kansas, under the direction of the late Dr. Robert Kennedy Duncan, in 1909 and 1910, and from the latter year until 1912 he carried out a comprehensive study of the ductless glands, during the course of which he investigated epinephrin from the whale. From 1912 to 1916 he was a Senior Fellow of the Mellon Institute of Industrial Research, having supervisory charge of all the Institute's investigations on the metallurgy and hydrometallurgy of copper and having direction of the experimental plant at Thompson, Nev. In connection with his investigatory work, he developed a process for the use of sulphur dioxide in hydrometallurgy

Edward Ray Weidlein

From July to October, 1916, Mr. Weidlein was Assistant Director of the Mellon Institute at Pittsburgh, and Associate Director from 1916 until 1921; he served as Acting Director during 1918-1919, and on October 8, 1921, was appointed Director. Mr. Weidlein was chemical expert to the United States War Industries Board from March 12, 1918, to January 1, 1919, and in 1918 he was chairman of the Fuel Committee of the National Research Council.

Mr. Weidlein is identified with the American Chemical Society, American Institute of Chemical Engineers, American Electrochemical Society, Society of Chemical Industry, American Association for the Advancement of Science, Engineers' Society of Western Pennsylvania, Franklin Institute, National Educational Association, Kansas Academy of Science, Societe de Chimie Industrielle of France, Washington Academy of Science, and Phi Upsilon, Sigma Xi, Phi Lambda Upsilon and Alpha Chi Sigma fraternities. His clubs include the Pittsburgh Athletic Association, University Club, and Pittsburgh Field Club, and the Chemists' Club and the Anglers Club of New York. He is president of the Faculty Club of the University of Pittsburgh.

Mr. Weidlein has been connected intimately with the Industrial Fellowship System since its beginning, and his research productivity played a conspicuous part in establishing the merit of the system when it was on trial first at the University of Kansas and later at the University of Pittsburgh. After the Mellon Institute of Industrial Research passed out of its "experimental stage" in 1916, Mr. Weidlein was given the opportunity to demonstrate his executive ability. His administrative power soon became evident, and he has had the most important part in bringing the Institute to its present high position. His optimism is boundless, and every effort of his, executive, educational, or social, is entered into with cheerful enthusiasm.

Museum Industrial Exhibit.

The committee, appointed by Chairman Handy, primarily for the purposes of the National Convention in September, consisted of Drs. Blough, Fieldner, James. Viol, Weidlein, and Zimmerman, and Messrs. Garratt and Munch, in addition to the chairman. Thanks to the activity of these men and the interest of the Director of the Carnegie Museum, a beginning was made at that time.

Several appropriate exhibits were already in the museum and these were assembled and increased so that during the convention the committee was able to show a very good exhibit representing the aluminum industry, sheet-iron and tin-plate, alloy steels from various makers, the cork industry, and the radium industry. Other exhibits were models illustrating the Bessemer and open-hearth steel processes, loaned by the Carnegie Institute of Technology; mine rescue apparatus, loaned by the United States Bureau of Mines; and refractories, heat insulation, and by-products of coal, loaned by the Mellon Institute of Industrial Research. There were also exhibits loaned by the Pittsburgh Testing Laboratory, and others representing the glass and electrical industries.

As a result of this endeavor there was aroused an interest which it is believed will continue and result in further development.

The present director of the Carnegie Museum, Mr. Douglas Stewart, is especially interested in building up a permanent exhibit, and through his knowledge and his ability to approach prospective exhibitors several new exhibits of value are under way.

Since September, little active work has been done by the Committee, but some additions have been made. The exhibit of the Aluminum Company of America, for example, has been notably enhanced by the addition of the aluminum statue of Charles Martin Hall, the inventor of the process for manufacturing aluminum by the use of electricity.

The work so far, however, gives only a hint of the possibilities and, being assured the support of the museum, every member of the Section is urged to aid in furthering developments.

ANNUAL BANQUET OF THE ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

The engineers of Western Pennsylvania gathered in the ballroom of the William Penn Hotel, January 22, with the largest attendance yet recorded in the long history of the organization.

Introduced by Mr. Morris Knowles, recently elected president of the Society, the toastmaster, George H. Neilson, president of the Braeburn Steel Company, well maintained his reputation as an enthusiastic interpreter of the ideals of the Pittsburgh engineering profession. He had no difficult task in introducing such nationally known speakers as Francis H. Sisson, vice president of the Guarantee Title & Trust Company, of New York; Charles Piez, president of the Link-Belt Company; Maj.-Gen. A. C. McDonnell, K.C.B., D.S.O.

Mr. Sisson's underlying thought of America's opportunity today is finely comprehended in his apt phrase of "Live and Help Live." His optimism concerning 1923 was marked.

Mr. Piez emphasized the tremendous importance of coal in our present industrial civilization.

Several passages will bear quotation:

"So strong is public resentment against the coal industry that unless the Fact Finding Commission, as it is called, will clean up many of the popular misunderstandings concerning it, the Government will step in and establish some form of control, to the loss of the industry and the everlasting cost to the public."

"Organized labor today absolutely controls a very large proportion of the coal production of the country. Nowhere has so complete a monopoly of labor been established, and nowhere are the evils of monopoly so well illustrated.

Maj. Gen. McDonnell drew upon his wealth of reminiscence gained through 18 years of personal contact with the rough, red-blooded men of the Canadian Northwest. His word pictures never failed to interest.

The officers of the Society are: Morris Knowles, president; Frederick Crabtree, vice president; Walter Spellmire, vice president; K. F. Treschow, secretary; A. Stucki, treasurer; G. A. Danforth, F. I. Ellis, L. F. W. Hildner, J. C. Hobbs, H. D. James, Richard Khnen, Jr., Strickland Knerse, G. T. Ladd, W. E. Moore, C. M. Reppert and F. G. Ross, directors.

STUDIES OF PHYSICAL PROPERTIES OF METALLURGICAL COKE

Employing testing methods standardized during the past year, a study will be made by the United States Bureau of Mines of the operation of blast furnaces in the Birmingham, Alabama, district in relation to the physical properties of the coke used as fuel.

Loss by "solution" of coke in the blast furnace stack gases is believed to be detrimental to economical operation. A laboratory test has been devised at the Southern Experiment Station of the Bureau of Mines, Birmingham-Tuscaloosa, Ala., by which the relative reactivity of cokes with carbon dioxide may be quantitatively determined. Correlation of test results with those of actual furnace practice will be undertaken during the present year. The work will be conducted in connection with furnaces operating on coke from Alabama, Pennsylvania and Illinois coal.

Experiments made in the Birmingham district during the past year will be supplemented by further work at furnaces in the Pittsburgh districts and at the furnaces of the St. Louis Coke and Chemical Company, at Granite City, Ill., which are operating on coke from Illinois coal. By means of analyses of gas taken from different parts of the blast furnace hearth, the rate of combustion of different kinds of coke will be determined under actual operating conditions.

In co-operation with the Fuel Section of the Pittsburgh Station of the Bureau of Mines, the relative combustibility of cokes from Alabama, Pennsylvania, and Illinois coal is being determined in the Kreisinger furnace. Rates of combustion as high as 100 lb. per square foot of grate area per hour are being employed. The influence of the size of the coke pieces is being investigated. Gas analyses at different points in the fuel bed are being made. The relation between tests results and furnace practice will be determined.

A study of the literature of low temperature carbonization is being made, and the suitability of Alabama coals for such treatment will be considered in connection with the work at higher temperatures.

WITH THE EQUIPMENT MANUFACTURERS

BRUSH EQUIPMENT FOR SYNCHRONOUS CONVERTERS

The National Carbon Company, Inc., now recommends complete brush equipment for synchronous converters. For the d.c. side they recommend their new electrographitic brush —259—which is a material of medium hardness. This brush has successfully replaced soft graphite brushes which have heretofore been considered essential on many types of d.c. machines. The soft graphite material is weak mechanically, and not only does it fail due to chipping and side wear, but on account of its mechanical weakness it has always been difficult to attach shunts which will keep a low resistance contact between the shunts and brush material. The new brush is recommended for d.c. service where the mica is undercut—speed up to 6000 ft. per minute, current densities up to 60 amps. per sq. in., voltage 80-600.

For the a.c. side of the converters they recommend Ringsdorff ET-10 for application at all speeds and voltages and usual current densities. A supplement to their catalog No. 37 giving characteristics and recommendations for 259 and ET-10 will soon be ready for distribution.

A NEW RECORDER FOR DETERMINING STEAM TURBINE ECONOMY

The Uehling Instrument Company, Paterson, N. J., has just developed and placed on the market a new combined barometer and vacuum record primarily for determining (1) the absolute back pressure in steam turbine and condensing plants, (2) the barometric pressure, (3) the condenser vacuum, (4) the existence of air leakage into the condenser, etc., and (5) the ability of the condenser to handle the load.

The existence of an unnecessarily high back pressure represents a waste in turbine steam consumption that is astonishing. In fact this waste is ordinarily larger than all the other power plant losses combined, with the exception of the heat lost up the chimney due to low CO_2 in the products of combustion. For example, for high pressure turbines, the relative steam consumption of the turbine per kwh. increases 1 per cent as the absolute back pressure increases from 1 to 4 in. of mercury (corresponding to a diminution in vacuum referred to a 30 in. barometer of from 29 in. to 26 in.). For low pressure turbines the corresponding increase in steam consumed per kwh. is 50 per cent.

The Uehling Combined Barometer and Vacuum Recorder consists merely of two float chambers, one of which is connected with a barometric mercury column, and the other with a mercury column in communication with the condenser. These columns and float chambers are secured to the recorder case. The pens are actuated by means of floats resting on the mercury in the two chambers. The movements of the floats correspond exactly to the changes in barometric pressure and in vacuum.

The measurement of barometric pressure and vacuum by means of mercury columns is standard for power plant testing, and therefore the readings of the Combined Barometer and Vacuum Recorder are at all times accurate and reliable. There is no necessity for calibrating the recorder against mercury column testers as is customary with instruments utilizing diaphragms, tube springs, and multiplying lever mechanisms.

The recorder draws automatically and continuously the barometer and vacuum records on the same chart. The barometer record is used as a base line for reading the absolute back pressure directly off the chart. As long as the two curves, barometer and vacuum, vary simultaneously and proportionately, everything is as it should be. Should, however, the vacuum fall when the barometer remains constant, either considerable air is leaking into the condenser, or the condenser is not able to handle the load.

NEW OIL CIRCUIT BREAKERS FOR INDUSTRIAL USE

A new line of oil circuit breakers, the type F-10 designed primarily for industrial applications, has been placed on the market by the Westinghouse Electric & Manufacturing Company.

The new breakers are of moderate interrupting ability and are made in capacities up to 200 amperes at 2500 volts and 300 amperes at 750 volts. They are wall-mounting breakers, designed for indoor service only. As they are dust-proof and drp-proof, they ma ybe used where dust is encountered and in mines where there is excessive moisture.

All type F-10 breakers are manually-operated and may be either non-automatic or automatic. The breaker is held in the closed position by a hardened steel roller, which is tied on the trigger so that when the trip coil is energized the trigger is raised, disengaging the latch and allowing the breaker to open. When the breaker is used non-automatic, it is tripped by raising the closing handle. When the breaker is in position, the operating handle is vertical and when the breaker is opened, the handle is raised slightly. It is thereby possible to determine the position of the contacts by the position of the handle.

Automatic operation is obtained by the addition of one or more automatic trip attachments. These attachments consist of series overload coils, with or without dash pot time limit devices, or of undervoltage release attachments, connected directly across the line for low voltages or to the secondary of self-contained or separate voltage transformers for 2500 volts. All automatic breakers are full-automatic, that is, it is impossible to hold the breaker in the closed position when a predetermined tripping condition exists.

The construction of the breaker is such that the entire equipment can be assembled, lined up, and the contacts and auxiliaries adjusted, either below or about the frame, before the tank or cover is placed in position, making possible quick and accurate replacements and adjustments.

The breaker frame or housing is made of heavy cast iron and the breakers are supported by bolting the frame proper to the wall or any flat vertical surface. The oil tanks are rectangular in shape and are made of heavy sheet iron with all seams lap-welded, the bottom being flanged and welded on the outside of the tank sides. Sufficient space is allowed in the tanks for oil expansion and for bubbles caused by the arc gases, so that no insulating lining material is needed.

The gases are vented through the clearance between the operating rods and the breaker framework and between the operating handles and the framework. The lifting lever, attached to the cross-bar, clamps the especially constructed wood operating rod and is operated through a toggle so constructed that the pressure on the contacts at the end of the moving contacts' travel is overcome easily by the operator during the closing operation.

NEW TYPE SMALL SINGLE STAGE PUMP

The De Lavel Steam Turbine Company was the first firm to produce the modern high efficiency centrifugal pump in the United States. The De Laval Company has always confined its manufacture solely to high grade pumps giving the best possible efficiency and so designed as to insure long life and the lowest possible cost of maintenance, but in sizes larger than the pumps described in this bulletin.

The recent demand for a better quality small pump at a reasonable cost has resulted in the De Laval Company developing the Type "F" pump and equipping a department so that this pump can be manufactured economically.

When buying a small pump the purchaser should carefully consider the following questions:

(1) Reliability; that is, the ability of the pump to operate continuously without trouble and without requiring an excessive amount of attention.

(2) Efficiency and ability to maintain efficiency during long periods of operation.

(3) Life; ease and cheapness of maintenance.

The De Laval Type "F" pump is designed particularly to insure reliability in service, and at the same time so designed as to require the minimum attention in operation. The main bearing is ring oiled, so that all that is necessary is to keep the oil reservoir filled. The bearing itself is very large, thereby insuring freedom from wear or hot bearings. Furthermore, all parts are carefully balanced, thus avoiding vibration, which is so destructive to the operation of any pump.

The De Laval Type "F" pump is of the most efficient design possible for small size pumps, and furthermore, it is so designed that it will maintain its efficiency during long periods of operation. No one today can afford to purchase an inefficient pump of any size, as the increased first cost is very much more than offset by the increased cost of operation.

These pumps are made in 1½ and 2-in. sizes, and are designed for capacities ranging from 5 gal. per min. against 10 ft. head up to 130 gal. per min. against 150 ft. head. They contain few and simple parts, which are manufactured to limit gages to insure interchangeability. Bulletin Type F gives very complete tables and instructions for selecting pumps for different conditions, and explain how to determine the proper speeds and how to select piping, valves, fittings, and driving pulley or motor to secure an efficient and satisfactory installation.

GRINDING AND PULVERIZING WITH CONICAL MILLS

It is a generally recognized fact that for the economic reduction of any material it is desirable to effect this reduction in steps or stages, removing that material which is sufficiently fine as soon as it is reduced.

Grinding is a "process" which must be carried out in a logical manner to produce results commensurate with the energy expended. Take for instance the crushing of a large rock as compared with a particle of sand. A heavy weight dropped from a considerable height is necessary to break the rock, but a tack hammer usually reduced the particle of sand to an incalculable powder. Reversing this action, the tack hammer would never be able to break the large rock, while the heavy weight in pulverizing the particle of sand would be so consuming far more energy than was necessary. In other words, the law of economical grinding is simply a case of proportioning the energy to the work to be performed. Another very important factor in the deduction of materials is to keep the particles undergoing reduction from getting imbeded in other particles already pulverized, for if the particles insufficiently ground are not kept separate, much more energy will be required to effect their reduction as it will be necessary to beat through this mass until the few remaining large particles have been reduced, while if the fine material has been previously cleared away, exposing the larger particles, their reduction is then a simple matter. Many artificial methods have been employed to take advantage of one or both of these two cardinal principles of grinding, but not until the Conical Mill was conceived has there ever been a device which by natural means approximated this ideal condition.

The new bulletin of the Hardinge Company treats the matter of pulverizing and grinding both wet and dry in a manner never before attempted by anyone. Although the Hardinge Mill itself has been in extensive operation for a number of years, the development which has occurred in the last three years has been so marked and our method of operation has been so changed that it became incumbent upon us to issue a new bulletin taking up this highly specialized field in a manner which should help the prospective buyer, no matter what type of equipment he finally decides to use.

It takes up the principles of grinding and how these principles apply to any class of material whether this grinding is to be accomplished wet or dry, or whether the product desired is to be as granular as possible or extremely fine and uniform in texture.

HOMESTEAD VALVE MANUFACTURING COMPANY OF HOMESTEAD, PA., ANNOUNCE IMPORTANT CHANGES IN THEIR WELL KNOWN HOMESTEAD QUARTER-TURN VALVE

The trend of steam pressures in the power plants and also in the various industrial processes—such as oil refining, chemical industries, etc.—has been in the direction of higher pressure and higher temperature. It has been found necessary, however, to adopt some method whereby a lubricant could be used and constantly renewed to meet some of the extreme cases. This lubricant introduced on the seating surface of the valve protects the metal from corrosion and the action of high temperature as encountered with super-heated steam. It insures easy operation, and a tight valve when shut off.

Homestead now has a series of valves on which this principle of lubrication has been added as a permanent feature. The "Homestead" Lubricated Valves resemble the regular quarter-turn "Homestead" valves in that they are of the plug cock type, opening and closing with a quarter-turn of the handle. In addition, the seat is protected at all times by a film of oil which prevents the fluid in the line from attacking the ground surfaces or depositing sediment between them.

The cam construction of the "Homestead" valve has been so changed that the plug is at all times held on the seat but not tightly enough to prevent the valve being operated easily. This cam also locks the valve plug tightly in the seat in the closed position as heretofore, with the exception that the change in design enables the operator to open the valve much more easily and removes any possibility of sticking. As the cam is of solid metal construction and is closely adjusted to allow the plug to turn easily while at the same time holding it on the seat at all times, it will not compress or change its form in any way and hence adjustments of this valve are unnecessary even after it has been in service for some length of time.

"Homestead" lubricated valves are made in all sizes up to six inches and for all pressures up to 350 pounds per square inch. They are particularly adapted for high temperature and unusual service of any kind, and the company's engineering staff is prepared at all times to consider any special requirements of valve users.

A complete new catalog and circulars describing the lubricated valve and the general line are now available and will be sent, upon request, to anyone interested.

NEWS OF THE PLANTS

The West Leechburg Steel Company, Farmers' Bank Building, Pittsburgh, Pa., has plans under way for the construction of an addition to its mill at Leechburg, Pa., comprising a one-story building, 120x700 feet, steel and reinforced concrete, estimated to cost in excess of $500,000, including machinery. The new building will be used primarily as a strip mill, and equipment will cost the greater part of the investment noted. A general contract for the plant has been awarded to the Treadwell Engineering Company, Easton, Pa.

The Columbia Steel Corporation, San Francisco, Cal., recently organized with a capital of $20,000,000, is perfecting plans for additions to its plant at Pittsburg, Cal., to include the construction of an addition to the open hearth department and for the erection of a number of new sheet and wire mills. A list of equipment to be installed will be arranged at an early date. Plans have also been arranged for the immediate construction of a new blast furnace at Provo, Utah, and work on this latter project will be pushed to completion. Wigginton E. Creed, president of the Pacific Gas & Electric Company, San Francisco, heads the new organization; Joseph Sloss is vice president and treasurer. The company comprises a consolidation of the Columbia Steel Company, with mills at Pittsburg and Portland, Ore., and the Utah Coal & Coke Company, Salt Lake City.

The Wheeling Steel Corporation, Wheeling, W. Va., has work under way on a new sintering plant at its East Steubenville works, and will arrangement for the equipment installation at an early date, to include special furnaces for the concentration of the flue dust from all of the blast furnaces in this district, and conversion into a solid for iron production. G. W. Hocking is secretary.

The McKinney Steel Company, Cleveland, Ohio, will soon commence the rebuilding of two blast furnaces at its River works, and proposes to convert the units, Nos. 1 and 2, heretofore hand-fired, into modern plants similar to the present No. 3 and 4 furnaces. The structures will be 22x90 feet, with capacity of 600 tons each, as compared with an output of 400 tons for the previous furnaces. The work is estimated to cost in excess of $200,000. The company has in prospect a new finishing mill, but is expected to defer active construction for a number of months to come.

The American Rolling Mill Company, Middletown, Ohio, is disposing of a preferred stock issue of $7,000,000, a portion of the proceeds to be used in connection with expansion at its mills at Ashland, Ky. In the near future a stock issue of $2,000,000 additional will be sold, the fund to be used for similar purposes. Work is under way on new finishing mills at the Ashland plant in addition to other miscellaneous structures, to increase the plant capacity from 300,000 tons to 500,000 tons per annum, making it the second largest plant in the country devoted exclusively to the production of sheets and light plates. Other structures will include a jobbing mill and galvanizing plant. George M. Verity is president.

The Youngstown Sheet & Tube Company, Youngstown, Ohio has completed negotiations for the purchase of the Steel & Tube Company of America, Inc., Chicago, Ill., which latter organization recently acquired the Brier Hill Steel Company with mills in the Youngstown district. The Steel & Tube Company plant will be used and expanded by the purchasing company for the production of steel pipe, making it the largest manufacturer in this line; the works of the Brier Hill Company will be continued for the manufacture of steel sheets. This latter organization has plans for extensions and improvements of its sheet mill at Niles, Ohio, to cost about $200,000, and this work will be carried out by the consolidated organization. James A. Campbell is president of the Youngstown company.

The Pressed Steel Manufacturing Company, 20 West Jackson Boulevard, Chicago, Ill., manufacturer of general pressed steel products, has plans nearing completion for the construction of a new plant at East Chicago, Ind., to consist of a main two-story building, with auxiliary structures, estimated to cost in excess of $500,000, including machinery installation. Property has been secured for the new plant, and ground will soon be broken. Frank D. Chase, Inc., 645 North Michigan Avenue, Chicago, is architect and engineer. Walter P. Murphy is president of the company.

The Standard Seamless Tube Company, 313 Sixth Avenue, Pittsburgh, Pa., has tentative plans under consideration for the erection of an addition to its steel tube manufacturing plant at Ambridge, Pa., estimated to cost approximately $85,000. It is expected to proceed with the work at an early date. H. E. Wharton is company engineer.

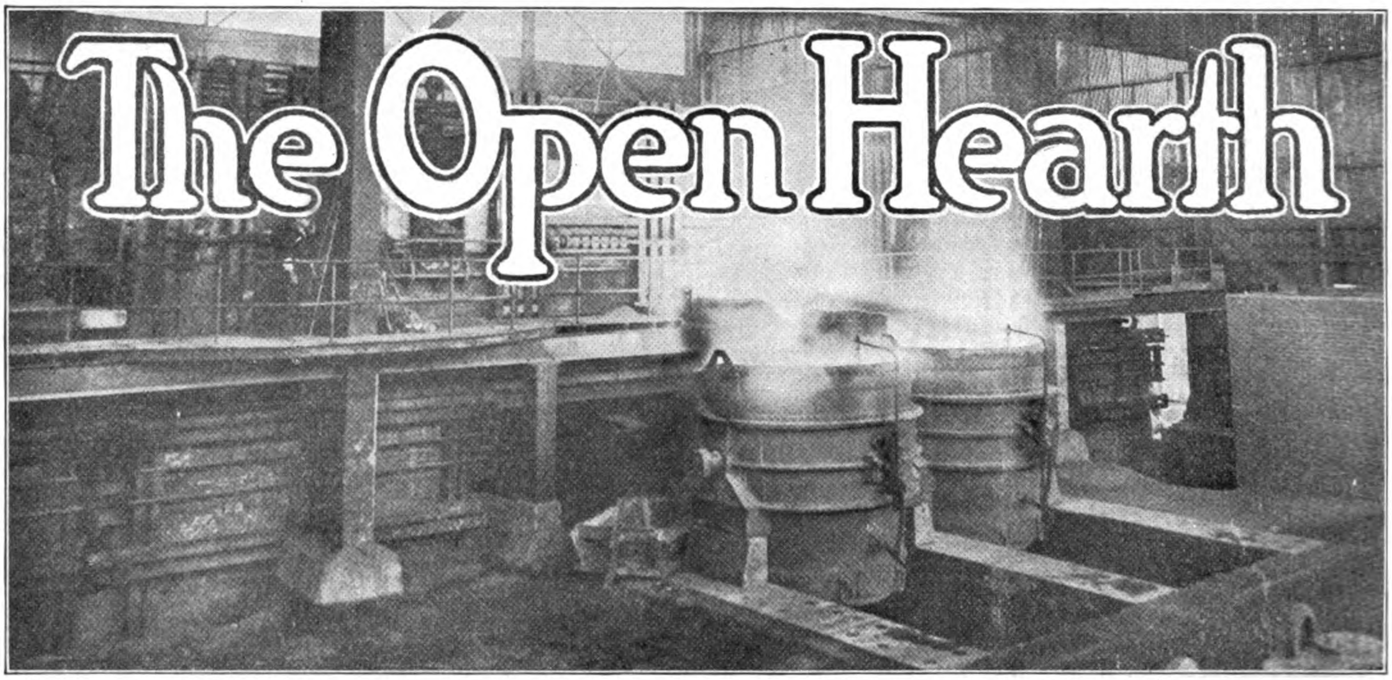
The Shenango Furnace Company, Sharpsville, Pa., has completed the rebuilding of its blast furnace No. 3, and the unit has been placed in service. The capacity has been increased from 350 to 500 tons per day, and it is expected to maintain capacity production for an indefinite period. The former stack will be rebuilt on the property of the Sharpsville Furnace Company, and is expected to be ready for operation in the near future. It will be modernized to a considerable extent.

The Newton Steel Company, Newton Falls, Ohio, is arranging for increased production at its plant, and three of the eight new sheet mills have now been placed in service. Construction work is in active progress on the other five mill units, and these are expected to be ready for operation early in April. With the new mills rolling, the company will have a maximum capacity of about 175,000 tons, chiefly highly finished steel sheets, per annum. E. F. Clark is president.

The Oliver Iron & Steel Company, 1001 Muriel Street, Pittsburgh, Pa., has acquired the plant and business of the Morris & Bailey Steel Company, with works at Wilson Station, near Clairton, Pa. The latter company has been specializing in the production of cold-rolled strip steel, and the new owner will continue the operation of the mill for this purpose. It is said that plans are under consideration for general expansion.

The United States Steel Corporation has plans nearing completion for extensions and improvements in the Lorain, Ohio, works of its subsidiary organization, the National Tube Company, to include at least one blast furnace, and a number of additions in the different steel mills. The production will be utilized at the local plant of the American Sheet & Tin Plate Company, another affiliated organization. This latter company is reported to be arranging for the erection of a new plant in this same district at Lorain.

The Open Hearth



Carey Wright, superintendent United States Radiator Corporation's plant, Dunkirk, N. Y., has resigned to become superintendent of the Detroit plant of the same corporation. John B. King, Dunkirk, N. Y., has been appointed to succeed Mr. Wright. Mr. Kink has been with the radiator plant four years.

M. E. Gomber, for more than 12 years in various capacities with the Bilton Machine & Tool Company, Bridgeport, Conn., has been made works manager.

L. D. Tracy has been appointed superintendent of the central experiment station of the Bureau of Mines at Urbana, Ill. He joined the bureau staff at Pittsburgh in 1918 and since has served as coal mining engineer. He succeeds J. J. Rutledge, resigned, at Urbana.

Ernest H. Woodmansee, for the past 27 years head foreman of the mill machinery manufacturing department, Brown & Sharpe Manufacturing Company, Providence, R. I., has resigned to accept a position as general superintendent of a large western manufacturing company.

Frank G. Walker has resigned, effective January 15th, as superintendent of the Bessemer department of the Republic Iron & Stel Company, Youngstown, Ohio. He will become superintendent of the new mechanical puddling plant being erected at Warren, Ohio, by the Youngstown Steel Company. Joseph Welsh, who has been assistant to Mr. Walker, will succeed him.

J. Leonard Replogle, chairman of the Replogle Steel Company and president of the Vanadium Corporation of America, has been elected a director of the Wickwire Spencer Steel Corporation, Buffalo and Worcester, Mass.

A. A. Garver has taken the position of general superintendent of the Empire Rolling Mill, Cleveland, moving to that city from Ashland, Ky.

James E. Strong has been elected vice president in charge of operations of the Alabama Company, Birmingham, Ala. He has been chief of the company. His promotion follows changes made a few weeks ago when Harry W. Coffin resigned as vice president and general manager and J. W. Porter, vice president and general sales manager, was elected to succeed Mr. Coffin.

Sir Robert Horne, who has held various high positions in the British government, including president of board of trade and chancellor of the exchequer, has been appointed a vice chairman of the Welsh steel firm, Baldwin, Ltd. This company is said to be the largest manufacturer of iron and steel in Great Britain and one of the largest in Europe. The main offices, where Sir Robert will have his headquarters, are at 33 St. Mary Axe, London, E. C. Sir Robert Horne has been associated with large business enterprises in Great Britain for many years.

C. W. Myers has been appointed superintendent of the McDonald bar mills of the Carnegie Steel Company, located at McDonald, Trumbull County, O. He was formerly general mill foreman and has been acting superintendent since the death of C. A. Miller, who served as superintendent from 1918, when the plant was built, until his death several weeks ago. Harry R. Mercer who has been superintendent of the roll shops, has been advanced to assistant superintendent of the plant. Both men have been with the Carnegie company over 15 years.

Thomas F. Beasley will be district sales manager in charge of motor and magnet sales of the St. Louis office recently opened by the Ohio Electric & Controller Company, Cleveland.

William G. Abbot, formerly in charge of the statistical department of the Consolidated Steel Corporation, has been appointed research director of the National Foreign Trade Council, India House, Hanover Square, New York.

E. W. Harrison, president and director of the Superior Steel Corporation, Pittsburgh, for the past six years, has resigned from that company.

C. F. Blue has resigned as director and president of the Carbon Steel Company, Pittsburgh, and W. W. Noble has resigned as secretary and director of the company, both resignations effective January 8th.

James Abercrombie Burden, vice president and chairman of the executive committee of the Eastern Steel Company, Pottsville, Pa., has been elected president of the company. He had been acting president since the resignation some years ago of Veryl Preston.

L. J. Campbell, chairman of the board of directors of the Atlas Steel Corporation, Dunkirk, N. Y., a merger of the Electric Alloy Steel Company and the Atlas Crucible Steel Company, has been elected president, and will serve in both capacities. As president he succeeds Arthur H. Hunter, of Buffalo, resigned. Mr. Hunter has also resigned as a director of the company.

Some Pointers on By-Product Coke Oven Operations

Low Temperature Tar and Its Evaluation[*]

By Joseph D. Davies[†]

Under present economic conditions, those enaged in the carbonization of coal would not look favorably on its carbonization for tar as the main by-product any more than they would consider ammonium sulphate in the same light. At present, tar has hardly a greater value than its market price as a fuel oil; in some plants—where tar is of poor quality, to be sure—it is looked upon as a nuisance rather than an asset. From the standpoint of the gas engineer, the production of low temperature tar involves a sacrifice of from 4,000 to 6,000 cubic feet of gas per ton of coal.

Low temperature gas is, of course, richer than high temperature gas, but the heating value of gas above 550 Btu. is not a consideration of great importance in current practice; rather is the tendency towards distribution of gas of lower heating value. In order, therefore, that low temperature methods become of interest to the gas engineer, the tar so produced must have a special value decidedly in excess of its fuel value—in fact, in excess of the value of the gas, which must be sacrificed in its production. Coke oven managers look upon low temperature tar in a somewhat different light. Its production involves a sacrifice of gas, which is not so important from their standpoint, since gas—and tar as well—is now used by them principally as an industrial fuel. They do, however, object to the quality of coke produced by carbonization at low temperatures; as judged from present standards it is not at all suitable for metallurgical processes, and prevailing metallurgical standards govern coke oven practice. Clearly then, low temperature carbonization methods do not harmonize at all with present industrial carbonization ideals. It may be said, however, that when it is a question of complete gasification, recovery of low temperature tar may become feasible; but even then it must have a special value in order that the extra expense involved in its recovery may be justified.

Lander[‡], after discussing the work of the British Fuel Research Board, concludes that profitable development of a low temperature industry must be based on coke as the main by-product. This is particularly true, he thinks, considering the fact that the coke obtained in the carbonization process amounts to 70 per cent of the raw coal; whereas the oil and gas amount to only about 8 per cent each. On the other hand, the Power Gas Corporation[§] recommends complete gasification with low temperature tar recovery, special Mond gas apparatus being used. Among the important advantages claimed for this process are: a high tar yield, 15 to 24 gal. per ton, 90 lbs. of ammonium sulphate per ton; and 120,000 cu. ft. of 178 Btu. gas. In general, the tendency among British investigators in the low temperature field is to look upon coke for use as domestic fuel as the main product to be sought in low temperature carbonization: the tar is practically taken at its valuation as a fuel oil.

In Germany, the demand for hydrocarbon oils of all kinds during the world war furnished an incentive for the development of methods for the production and utilization of low temperature tar oils to a stage far beyond that reached in other countries. In all German low-temperature processes, therefore, great care is taken to conserve the oils, if need be at the expense of the gas and coke. In fact, any process that could be made to yield lubricating oil stock, motor spirit stock, or fuel oil, was promptly modified with that end in view. Developments since 1918 have apparently been along the same general lines.

Characteristics of Low Temperature Tar Oils.

Much has been written of the characteristics of low temperature tar oils and as many analyses have been published of tars from as many different processes, so the results are confusing and difficult to interpret. This is mainly because low temperature tar is evolved within a temperature range where it is very sensitive to heat, and a little difference in time of exposure to heat or variation in the intensity of the heating will cause a disproportionate change in the composition of the tar. In many cases where analyses are reported, the exact conditions under which the coal was distilled are either incorrectly given, or not even closely approximated. The low temperature tar referred to in the literature may mean tar generated anywhere within the range of 450 to 800 deg. C., with the figures for yield, and particularly the quality of tar, varying widely. With high temperature tar, the case is different since here the decomposition reactions have advanced to a stage where the tar is much less sensitive than it is in the former case, and accordingly, analyses of high temperature tar agree more closely.

From the above it must not be assumed that it is never economical to produce mixed or partly cracked tars. The writer believes that it is not possible with most coals to make a good semi-coke without decomposition of the tar to some extent, in which case the gas yield will be materially increased, thus compensating partly for the depreciation in quality of the tar. It cannot be said with confidence that a mixed tar will ultimately prove of less value in the United States than true low-temperature tar. All intermediate tars are partly cracked primary tars; the heaviest oils, particularly the resins, disappear, and their products are found in the gas and light oils. It might be inferred, therefore, that where the purpose is to obtain motor spirit stock and fuel oil, it is best to produce a cracked tar. That moderate cracking produces a better semi-coke and a higher gas yield has been demonstrated in the Bureau of Mines laboratories at Pittsburgh. Most low temperature methods developed in England have been devised for the production of a good semi-coke, and incidentally a cracked tar suitable for motor spirit and fuel oil, with attendant high gas yields. The Germans, on the other hand, work primarily for the uncracked primary tar, preferring to separate this into fractions which may be cracked or otherwise refined as the market may demand. They are not interested in producing coke in a form suitable for domestic use, and they do not wish to make gas at the expense of tar; their main object being to produce substitutes (ersatz) for petroleum fuel oils and lubricants, which they must now import.

Primary Tar.

True primary tar, the so-called urteer of German writers, is that obtained from coal at the lowest practical distillation temperatures, usually by maintaining a high vacuum on the carbonization chamber, or, more practicably, by the circulation of steam or other inert gases during carbonization.

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[*] Part of a paper presented before the 1922 convention of the American Gas Association. Published by permission of the Director of the U. S. Bureau of Mines.

[†] Fuels Chemist, Pittsburgh Experiment Station, Bureau of Mines.

[‡] C. H. Lander, "Low Temperature Carbonization of Coal," Gas Journal, vol. 158, 1922, pp. 205-6.

[§] Communication from the Power Gas Corporation, "Improved Low Temperature By-Product Recovery Gas Producess Process," Iron Coal Trades Review, vol. 104, 1922, p. 576.

TRADE PUBLICATIONS

Turbines, Pumps, Compressors—Under the title of "Plant and Products," the De-Laval Steam Turbine Company, of Trenton, N. J., has published a 24-page booklet briefly describing the single and multi-stage steam turbines, centrifugal pumps, blowers and compressors, and speed reducing gears in which that concern has specialized since its establishment in 1901. In the present manufacturing plant, containing approximately 275,000 sq. ft. of floor space, all lines of manufacture are conducted on an interchangeable basis with limit gauges throughout, including a comprehensive system of inspection, each part being marked with an identifying symbol and with an inspector's mark.

Uehling Instruments — The Uehling Instrument Company, Paterson, N. J., has just issued a 12-page folder which explains concisely the two biggest losses in the steam power plant, namely (1) the loss in steam turbine economy due to air leakage into the condensing system and (2) the sensible heat in the flue gases lost up the chimney. A table gives data on steam turbine economy as related to the absolute back pressure. The Uehling Combined Barometer and Vacuum Recorder, as illustrated in the folder, is in effect an automatic log of condenser performance because it records the existing vacuum as well as the absolute back pressure for every second of the day. The chart is legible to less than 1/20 inch of mercury between the range of 0 to 6 pounds back pressure thus detecting air leakage into the condenser, exhaust piping or turbine casing and showing whether or not the condenser is large enough to handle the load under any given conditions. Data on combustion are given in another table, such as the variation of the chimney loss with the percentage of CO_2 and its relation to flame temperature and ratio of air to fuel supply. The Uehling CO_2 Recorder and Indicator are illustrated and 12 different kinds of important information which these instruments furnish are cited. A list of prominent users of Uehling equipment and a list of Uehling bulletins are also appended in the folder.

Crane Parts — The Whiting Corporation, Harvey, Ill., has issued a new booklet on the operation and maintenance of Whiting Electric Cranes. It includes lists of parts, together with cuts and diagrams making it easy for the user to order repair parts.

TRADE NOTES

The Ohio Electric & Controller Company, Cleveland, Ohio, announce the appointment of the Southern Industrial Engineering Company, Inc., American Trust Building, Birmingham, Ala., as their representatives for the sale of Ohio Magnets in the state of Alabama. They also announce the opening of an office in St. Louis. Mr. Thomas E. Beasley will be in charge.

The Dodge Sales and Engineering Company, Mishawaka, Indiana, which has for the past eight years been operating as the selling subsidiary of the Dodge Manufacturing Company and Dodge Steel Pulley Corporation, has now been consolidated with the parent company, Dodge Manufacturing Corporation, which was organized and began business last July. The Dodge Manufacturing Corporation at that time took over the two long established manufacturing concerns, Dodge Manufacturing Company organized in 1880 and Dodge Steel Pulley Corporation organized in 1917 as the successor of the Oneida Steel Pulley Company which began the manufacture of steel pulleys in 1900.

The distribution of Dodge products, which has heretofore been done under the name of the Dodge Sales and Engineering Company, will hereafter be conducted by the Sales Department of the Dodge Manufacturing Corporation with Duncan J. Campbell, General Sales Manager, in charge and John A. Beynon, Assistant General Sales Manager.

The District Sales Organization of the Dodge Sales and Engineering Company will be continued as branches of the Sales Department of the Dodge Manufacturing Corporation.

Freyn, Brassert & Company, Chicago, Ill., have been retained as Consulting Engineers by the Algoma Steel Corporation, Ltd., 'Sault Ste. Marie, Ontario, Canada, in connection with the remodeling of their No. 3 furnace and hot blast stoves.

After two years of satisfactory operation with powdered coal firing of 22 sheet and pair and annealing furnaces, the Otis Steel Company has started extensions at their plant in Cleveland for the erection of a complete new strip mill, which provides for powdered coal firing of continuous heating and annealing furnaces.

In this plant, which gives consideration to quality as well as tonnage, it has been found as a result of two years' operation with powdered coal that this method of firing not only is economical and reliable but that the product in general is improved and metal losses are materially reduced.

The complete Quigley system now in use for preparing distributing and burning the fuel is being extended to serve all furnaces in the new strip mill. Order for the powdered coal equipment has been placed with Quigley Fuel System, Inc., 26 Cortlandt Street, New York.

Work is well under way on the new $700,000 building being constructed for the Westinghouse Electric & Manufacturing Company in Chicago. The building, which is located at West Pershing Road and Leavitt Street, will be used for a combination district sales office, warehouse, and service shop and is the first o fthree buildings to be erected at this location. It will be seven stories high, will contain 218,000 sq. ft. of floor space, and will be of reinforced concrete construction. Work was started November 1st and will be completed about the first of May.

The Koppers Company has received a contract from the Columbia Steel Company covering the erection of a By-Product Coke Plant at Salt Lake City, Utah, in connection with the blast furnace to be installed at that point. The by-product coke plant will consist of 33 ovens of the Koppers Company's new design, having a capacity for carbonizing approximately 1,000 tons of coal per day. It is interesting to note in this connection that Utah coals will be used, this being the first installation of by-product ovens to carbonize such coals.

Before giving the contract to the Koppers Company, the Columbia Steel Company made thorough investigation of all of the different types of by-product ovens being built in this country, especially to determine the best type available for carbonizing the high volatile Utah coals.

Construction work will be started at once and it is expected that the plant will be completed in about a year's time.

COMING MEETINGS

February 14-16 — American Institute of Electrical Engineers will hold its midwinter convention in New York. F. L. Hutchinson, 29 West 39th Street, New York, is secretary.

February 19-21 — American Institute of Mining and Metallurgical Engineers will hold its annual meeting in Engineering Societies Building, New York. E. F. Sharpless, 29 West 39th Street, New York, is secretary.

April 3-7 — American Chemical Society, will hold its spring meeting in New Haven, Conn. L. Parsons, P. O. Box 1515, Washington, is secretary.

May 3-5 — American Electrochemical Society will hold its semi-annual meeting in Hotel Commodore, New York. Colin G. Fink, 327 So. La Salle Street, Chicago, is secretary.

June 25-26 — American Society for Testing Materials annual meeting will be held at the Chalfonte-Haddon Hall Hotel, Atantic City, N. J. C. L. Warwick, 1315 Spruce Street, Philadelphia, is secretary.

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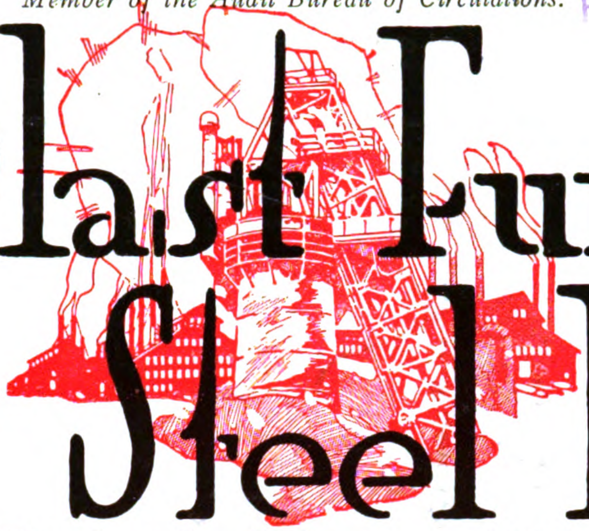

The Blast Furnace and Steel Plant

Pittsburgh, February, 1923.

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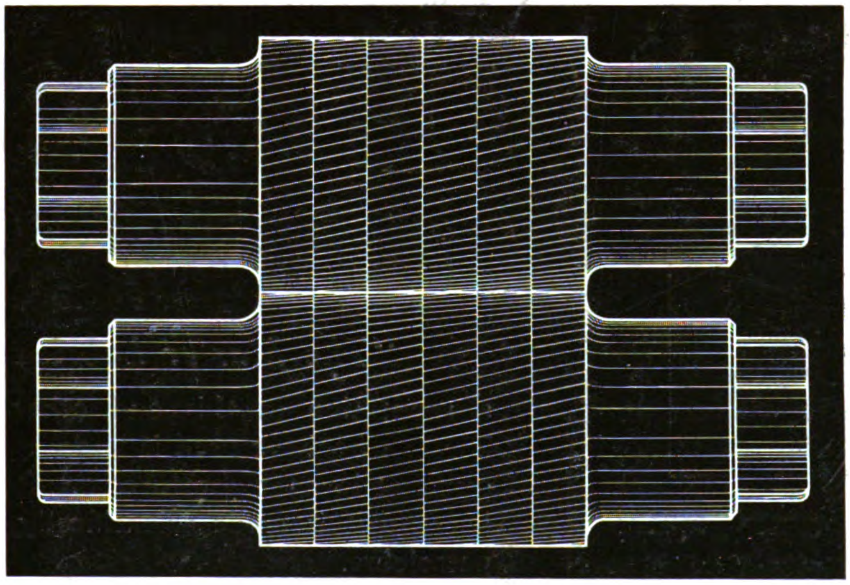

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